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Fact Vs. Fiction in the New Mexico Desert

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8. Memo, Brig Gen Tom C. Rives to Maj Gen Curtis LeMay, subj: Relief of Major R.T. Crane as Project Officer for MOGUL and TORRID, June 18, 1946

9. Memo, Maj Gen Curtis E. LeMay to Maj Gen L.C. Craigie, April 16, 1947

10. New York University, *Constant Level Balloons, Final Report,* March 1, 1951

11. New York University, *Constant Level Balloons,* Section 1, *General,* November 15, 1949

12. New York University, *Constant Level Balloons,* Section 3, *Summary of Flights,* July 15, 1949

13. New York University, *Technical Report No. 1, Constant Level Balloon,* April 1, 1948

14. Athelstan F. Spilhaus, C.S. Schneider, C.B. Moore, "Controlled-Altitude Free Balloons," *Journal of Meteorology,* Vol. 5, August 1948

15. New York University, *Progress Report No. 6, Constant Level Balloon,* Section II, June 1947

16. New York University, *Special Report No. 1, Constant Level Balloon,* May 1947

17. Personal Journal of Albert P. Crary

18. New York University, *Progress Report [No. 7], Constant Level Balloon,* Section II, July 1947

19. New York University, *Progress Report No. 4, Radio Transmitting, Receiving and Recording System for Constant Level Balloon,* [Section I], April 2, 1947

20. Interview, Col Jeffrey Butler and 1st Lt James McAndrew with Professor Charles B. Moore, June 8, 1994

21. Report, Holloman AFB, "Progress Summary Report on U.S.A.F. Guided Missile Test Activities," August 1, 1948

22. Interview, [Col Jeffrey Butler and 1st Lt James McAndrew with] Col Albert C.Trakowski, USAF (Ret., June 29, 1994

23. Report, Cambridge Field Station, Air Materiel Command, "Review of Air Materiel Command Geophysical Activities by Brigadier General D.N. Yates, and Staff, of the Air Weather Service," February 10, 1949

24. New York University, *Constant Level Balloons,* Section 2, *Operations,* January 31, 1949

25. Combined History, 509th Bomb Group and Roswell Army Airfield, September 1–30, 1947

Attachment to Colonel Weaver's Report of Air Force Research:

33. Mensuration Working Paper, with Drawing and Photo

Photograph Section

14

Athelstan F. Spilhaus, C.S. Schneider, and C.B. Moore
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CONTROLLED-ALTITUDE FREE BALLOONS

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(Manuscript received 4 December 1947)

ABSTRACT

The results of an experimental program to develop balloons with associated control devices, which will float at constant pressure in the atmosphere, are given.

Newly developed plastic balloons and automatic ballast equipment are described. Examples of successful controlled-altitude flights are shown, together with a preliminary analysis of their trajectories.

The constant-level balloon may provide data not obtainable from an ordinary pilot-balloon network. Future possibilities and plans for its use are indicated.

1. Purpose

Drift bottles have been used for many years in the study of ocean currents and have provided interesting data. In meteorology, no corresponding device has been available. It is evident, however, that a balloon which is free to move with the air currents, and yet whose altitude can be controlled, has many important applications in meteorology, as well as in other fields, where it may be desired to keep instruments at altitude for considerable lengths of time. An example is in the investigation of cosmic rays; here, clusters of ordinary extensible meteorological balloons have been used, but the constancy of altitude obtained is not sufficient for many meteorological applications. The purpose of the present investigation[1] was to develop a balloon with a control system which would fly at a predetermined constant level for periods of many hours. Such a balloon has wider application than the ocean drift bottle, because, whereas the latter is limited to surface (or near surface) currents, controlled free balloons may be set to drift at any pressure elevation desired, or along other thermodynamically defined surfaces, as long as the element defining the surface changes in a monotone fashion in the vertical.

In addition to the uses for maintaining instruments at high elevations, there are numerous potential applications of these balloons. Direct measurements of air trajectories and of lateral diffusion become possible. The balloons may also be used as vehicles to convey and drop radiosondes over ocean areas. One problem in this application is to obtain an absolute altitude tie-in point, as it will be difficult to identify the point at which the radiosonde reaches the sea surface.

2. Earlier attempts

There have been numerous attempts for various purposes to get a balloon or group of balloons to stay at a fairly constant altitude. Meisinger was interested in the meteorological aspects of this, using a manned balloon. In the investigation of cosmic rays, as for example, by Clarke and Korff (1941), clusters of ordinary meteorological balloons, 350-gram or 700-gram size, numbering anywhere from twenty to nearly seventy, were utilized. No altitude-control devices were used; the balloons were merely given different amounts of inflation. Thus the whole train ascended to an altitude where certain of the more highly inflated balloons burst until the remainder just balanced the load; thereafter, the assembly descended slowly due to loss of lift by the diffusion of gas. The only provision for having the system regain altitude if it descended too low was by arranging the launching before dawn, so that after the bursting of the first balloon and the subsequent descent, superheating of the balloons by the rising sun would cause the whole assembly to rise again, thereby increasing the duration of the flight. The system does not have sufficient control for many purposes.

The much-publicized use of balloons by the Japanese in the last war represents an attempt which must be considered highly sucecessful from the point of view of the length of time which the balloons stayed in the air. Here the objective was not to obtain any critical altitude control, but rather to insure that the balloons remained floating. The Japanese nonextensible balloons were of two types. One type was of heavy paper, coated to minimize diffusion, of spherical shape, about 25 to 30 ft in diameter, and containing about 19,000 cubic feet of gas. A solid-ballast control system was utilized and gas was valved at a low internal pressure (about two inches of water) to prevent the balloons from rupturing due to the increase of the internal pressure by altitude fluctuations or radiation changes. Such a valve tends to conserve the lifting gas but acts as a safety device to prevent damage of the envelope due to too great an internal pressure.

The solid-ballast system was complex; approximately 900 pounds of sand was used on each balloon, distributed in thirty-six bags. The dropping of ballast

[1] Sponsored by, and in cooperation with the Watson Laboratories of the Air Materiel Command.

was controlled by a baroswitch arrangement which dropped a bag by igniting a fuse when the altitude fell below any one of four different levels between 25,000 and 5000 ft. In addition, a delay mechanism consisting of a two-minute fuse was arranged between successive switches so that after ballast was dropped, two minutes would be allowed for the balloon to regain its altitude; if it did not regain in this time another bag of ballast would be dropped. The system was inefficient because if any one of the thirty-six fuse arrangements failed, no more ballast was dropped.

The second type of Japanese balloon was similar, in general, but slightly larger; it was made of oiled silk and therefore would stand a greater internal pressure (approximately six inches of water). The higher the internal pressure that the balloon can stand, the less gas need be valved under conditions of superheating or altitude fluctuations. The Japanese released many balloons of these types from their islands and estimated five to seven per cent of those released reached the west coast of this country. The balloons floated between the surface and 30,000 ft above sea level; those which reached the west coast must have remained aloft from four to ten days. While the altitude maintained was not constant, these balloons were highly successful for the time they remained in the air.

An attempt in this country was made in 1943 by the Dewey and Almy Company, to obtain constant-level balloons which would float at altitudes up to 15,000 ft. An ordinary 350-gram meteorological balloon was used but its volume was controlled by a nonextensible shroud around it. With this method a flight at about 5000 ft was obtained at fairly constant altitude for about an hour and a half.

3. Design of controlled-altitude balloons

As a result of the Japanese and other experiments, the use of a nonextensible envelope for the balloons was indicated. If a perfectly nonextensible balloon could be built with no diffusion through the walls, and which could withstand a high internal pressure, it would automatically stay at a constant density where the buoyancy of the full balloon equaled the load. In practice, control devices are needed to offset the leakage and diffusion of gas, to compensate for vertical currents in the atmosphere, to correct for the motion of the balloon due to diurnal changes of the balloon's temperature, and to compensate for the valving of gas which is necessary to prevent rupture of the envelope. It was decided to use a plastic as the balloon fabric, as some modern plastics are quite transparent to radiation, strong, easily fabricated, and relatively inexpensive as compared with coated fabrics.

A. Choice of plastics.—In the selection of a plastic material of which to make the balloons, the desirable properties are: (a) low brittle temperature, (b) low permeability, (c) high tensile strength, (d) high tear resistance, (e) chemical stability, (f) high radiation transmission or reflection. *Polyethylene* soon recommended itself for use, with its brittle temperature of below −80F. It is apparently unaffected by ultraviolet and ozone. The permeability through one mil of thickness and one square meter of area for 24 hours is ten liters for hydrogen and seven liters for helium, at normal atmospheric temperature and pressure.

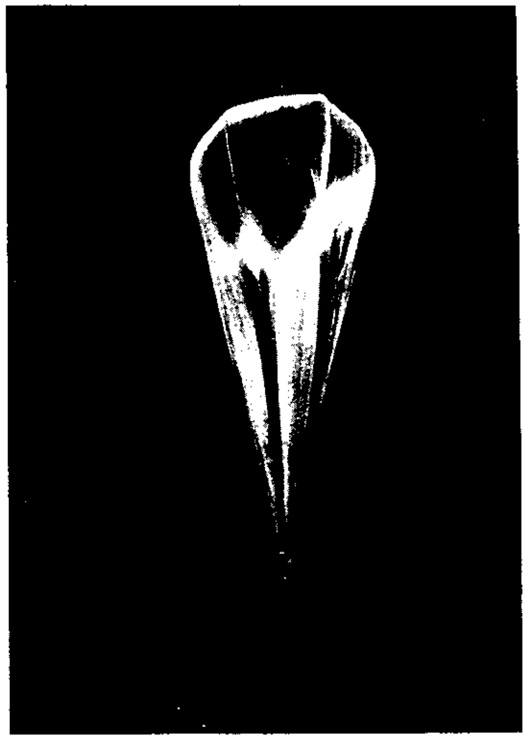

FIG. 1. Polyethylene balloon, 20-ft diameter.

Polyethylene is also relatively easy to fabricate. It has an ultimate tensile strength of 1,900 pounds per square inch at 25C, which, in a 15-ft balloon made out of four-mil fabric, represents a working pressure of about 2.3 inches of water. The tensile strength at the temperatures at which the balloon flies at high altitude may be more than three times the value quoted above.

Fig. 1 shows a polyethylene balloon[2] flown successfully in Flight 26 described below. Another film investigated is *Saran*, which has ten times the tensile strength of polyethylene—three times the strength across the seams. Saran has a higher transparency and one-thirtieth the permeability of polyethylene. The effective brittle temperature of Saran for this work is not known reliably.

B. Ballast valve.—The altitude control is an automatic ballast-dropping device[3] consisting essentially of

[2] Made by General Mills, Inc.
[3] Made by Kollsman Instrument Division of Square D Company.

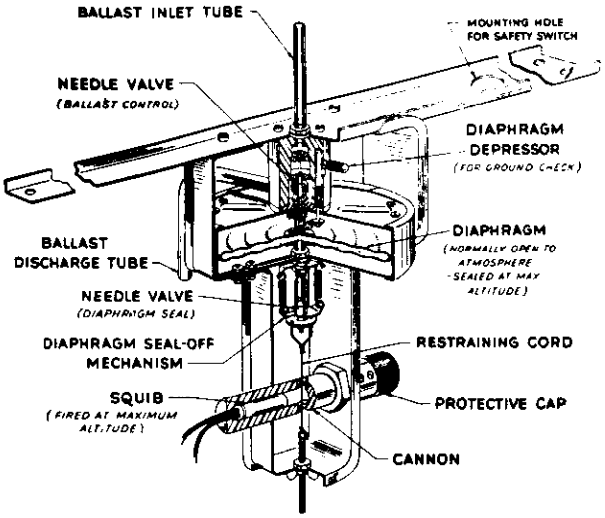

FIG. 2. Automatic ballast valve.

a diaphragm-operated needle valve which jettisons liquid ballast whenever the balloon is below the altitude at which the control is actuated. This is shown in fig. 2. The ballast reservoir (fig. 3), in general, can hold 15 kilograms of the liquid ballast—usually compass fluid, a highly refined kerosene-type petroleum product. When the atmospheric pressure outside the diaphragm is 5 millibars above the internal pressure, 160 grams of ballast per minute flow under a one-foot head. When the automatic ballast valve is wide open, which is after 6.5 millibars increase over the internal pressure, 300 grams per minute flow. These values may be compared with a diffusion loss of lift of the order of magnitude of 10 grams per hour from the thicker 15-ft balloon described below. Quite positive altitude control can be obtained.

Efforts are made to cause the static rate of leakage, *i.e.*, the leakage which proceeds when the automatic ballast valve is closed, to exceed slightly the rate of loss of lift due to the diffusion of the lifting gas from the balloon. To facilitate setting the fixed leak, a manually operated ballast valve, consisting of a leak adjustable by means of a fine needle valve, is added to the ballast-release assembly.[4]

C. Minimum pressure switch.—Obviously, the automatic ballast valve must not be in operation while the balloon is rising, as this would be a waste of ballast. Therefore the automatically operated needle valve is closed until the balloon reaches altitude. This is accomplished by having the loaded diaphragm of the altitude control open to the atmosphere until the balloon descends from a minimum pressure. At this time, an electrical contact is made and a squib[5] cuts a restraining cord and allows a needle valve to seal off the diaphragm from any further access to the air (fig. 2). The capsule then contains a volume of air which has been trapped at the existing pressure and temperature, at the time of operation of the sealing switch. Thereafter the aneroid will withdraw the ballast-control needle valve when the ambient pressure increases to the point where the entrapped air is compressed below this volume.

Fig. 4 shows the minimum pressure switch which makes the electrical contact at the time of seal-off. It consists of a trapped volume of air that is allowed to escape through a mercury pool as long as the outside pressure is decreasing. As soon as the exterior pressure increases once more, however, mercury is drawn into the tube, making the seal-off contact between two electrodes.

4. Height determination

Up to the present time, the standard radiosonde has been used in order to determine the altitude at which the balloon is flying. This permits a regular radiosonde ascent to be obtained during the period that the balloon is rising. Thereafter, as the balloon remains at approximately the same altitude, it becomes somewhat difficult to identify the radiosonde contact, but utilizing both the temperature and pressure indication, this is possible. A special radiosonde modulator of the Olland type has been designed (fig. 5). The pressure

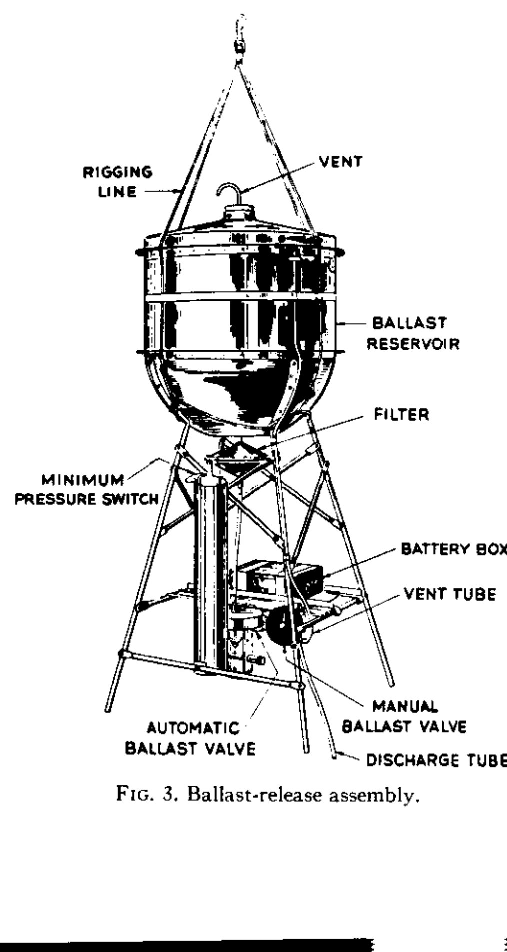

FIG. 3. Ballast-release assembly.

[4] Since this manuscript was written, the procedure has been simplified. Only a simple fixed leak is used for daytime flights. The automatic ballast valve is used alone for flights through sunset or sunrise.

[5] A small electrically detonated charge.

capsule and linkage is of conventional design but in place of the commutator bar, a motor driven helix is employed. This system permits the determination of

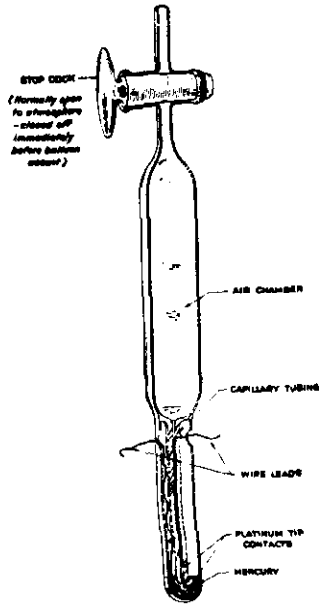

Fig. 4. Minimum pressure switch (mercurial).

pressure data without knowledge of the history of contact sequence or of the ascent or descent of the balloon, as is required in the conventional radiosonde.

5. Tracking of the balloon

The balloons that have been flown by the writers usually have been tracked by theodolites. Airplanes have also been used, to extend the observations. These two methods require the balloon to be visible and not obscured by cloud cover. When available, ground radar has been used in tracking the balloons, with good results.

A series of SCR 658 radio direction-finders is also used, arranged in a net along the expected trajectory of the balloon. In addition, aircraft equipped with inverted search radar have been employed to extend the tracking net.

6. Flight results

While the characteristics of various plastics were being investigated, four preliminary flights were made with clusters of ordinary meteorological balloons, from 16 to 26 in number, to which two to four towing balloons were attached. The towing balloons were cut free by a baroswitch at a predetermined altitude. The remainder of the balloons were inflated so that they exactly balanced the load hung from the cluster. To offset diffusion, sand was dropped from an arrangement of tubes, 9 to 16 in number, each containing about 200 to 1500 grams of sand ballast. This ballast was dropped by a baroswitch mechanism on descent only. Some of these flights were relatively successful as a beginning method but the dropping of discrete quantities of sand caused too great fluctuation of altitude and therefore was abandoned later. The first successful flight stayed at 51,000 ft, plus or minus 100 ft, for 38 minutes; another remained between 30,000 and 40,000 ft for 147 minutes. The latter shows the same characteristic time-altitude curve as the cosmic-ray clusters, although its altitude control is superior. It is not believed that much improved altitude control can be obtained, utilizing ordinary meteorological balloons. Flight termination was usually due to deterioration of the balloon caused by the sun.

In the first flight utilizing plastic balloons, a cluster of ten seven-foot diameter balloons[6] was used. The load on the cluster was 16.5 kilograms. An altitude control was used. Unfortunately, the maximum altitude reached was not as high as the predetermined altitude which was selected to seal the diaphragm of the automatic ballast valve. As a result, the cluster rose to ceiling and stayed at this altitude for a short while. Diffusion and leakage of helium produced a loss of lift at the rate of 125 feet per minute.

The next flight was made with a single polyethylene balloon, 15 ft in diameter. To insure sealing-off, the ballast-release diaphragm was set to operate at an altitude of 12,000 ft, considerably below the calculated ceiling of the balloon. After a dawn release the balloon continued to ascend to 15,100 ft where it leveled off, then slowly descended to 9000 ft due to diffusion losses. At this altitude the ballast release began to operate and thereafter the balloon maintained its altitude within ±1300 ft for a period of 4½ hours before the radio signal was lost. However, in the first two hours of this period, before the convection currents

[6] Made by General Mills, Inc.

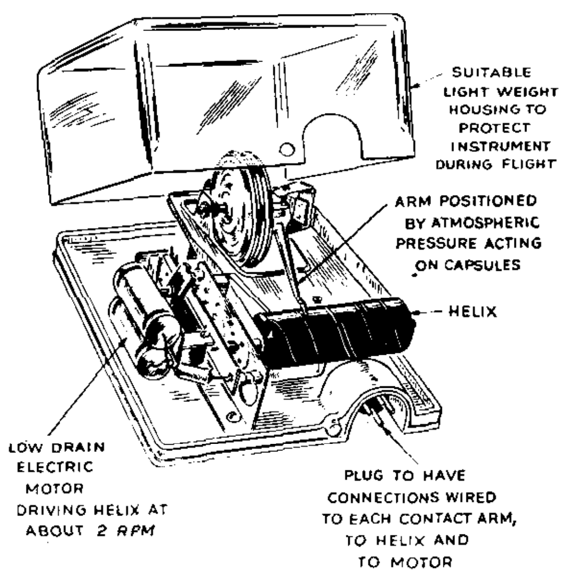

Fig. 5. Olland-cycle pressure modulator.

from the desert set in, the balloon maintained an altitude of 9200 ± 150 ft.

An explanation as to why the ballast release functioned at 9000 ft, although it was set to operate at 12,000 ft, is plain from the following data. The air in the diaphragm was sealed off on the dawn ascent at 12,000 ft, where the pressure was 657 mb and the temperature 9C. However, by the time the balloon passed through this level during the slow descent, the instrument temperature was 19C. This means that the pressure of the air trapped inside the diaphragm was higher than it was at time of seal-off.

For the ballast valve to function, the balloon had to descend to a pressure which would be greater by about 3 mb than the pressure of the trapped air at its now higher temperature. Of course, there was little ventilation past the instrument, and therefore the instrument temperature was about 25C above the ambient temperature after the sun had risen.

The automatic ballast valve operates when the volume inside the sealed diaphragm becomes slightly less than the volume at seal-off. Denoting the altitude at which it can operate by the subscript h, the pressure divided by the temperature at this altitude will equal the pressure at the seal-off altitude divided by the trapped-air temperature at the time of seal-off; in this case

$$p_s = 657 \text{ mb}$$
$$T_s = 9\text{C} = 282\text{A}$$
$$T_h = 39\text{C} = 312\text{A},$$

where the subscript s refers to seal-off. Thus the pressure at altitude h is given by

$$p_h = p_s T_h / T_s = 727 \text{ mb}.$$

This pressure, at which ballast release will begin, corresponds to an altitude of 9000 ft, which is the observed altitude maintained by the balloon for nearly 4½ hours, until the radiosonde tracking signal was lost. The theodolite lost the balloon in clouds earlier and the airplane observer never succeeded in seeing it, so the balloon may have remained for a considerably longer period at this altitude. Eleven hours after beginning the ascent, the balloon was reported to have been seen over Albuquerque, New Mexico, and about 26 hours later a report was made from Pueblo, Colorado, which seemed to indicate that the balloon was still in the air at that time. The meteorological situation and wind data for that area at the time of flight support the contention that the latter observations were of the same balloon.

The next flight consisted of an assembly of various balloons, as follows:

One 15-ft diameter 0.008-inch polyethylene balloon,
Six 7-ft diameter General Mills 0.001-inch polythene balloons,
Two 350-gm meteorological balloons for stadia measurements.

The single balloon had a measured diffusion loss of lift of 4 grams per hour. The General Mills balloons were observed to lose lift at the rate of about 100 grams per hour per balloon.

Three of the 7-ft balloons were inverted and deflated shortly after launching, due to differences in the rates of rise of the various balloons in the cluster. Therefore, the altitude reached was not high enough to effect seal-off. (It is for this reason that the minimum pressure switch was developed for use in later flights.)

Fig. 9 shows the elevation and plan views of the track of this flight. The train leveled off at 16,500 ft. The diffusion loss of lift of the remaining balloons was approximately 300 grams per hour. The ballast valve used had an unusually high rate of static leakage which had been measured before release and found to be 310 grams per hour. Thus fortuitously, the loss of lift was compensated by ballast leakage. This nearly

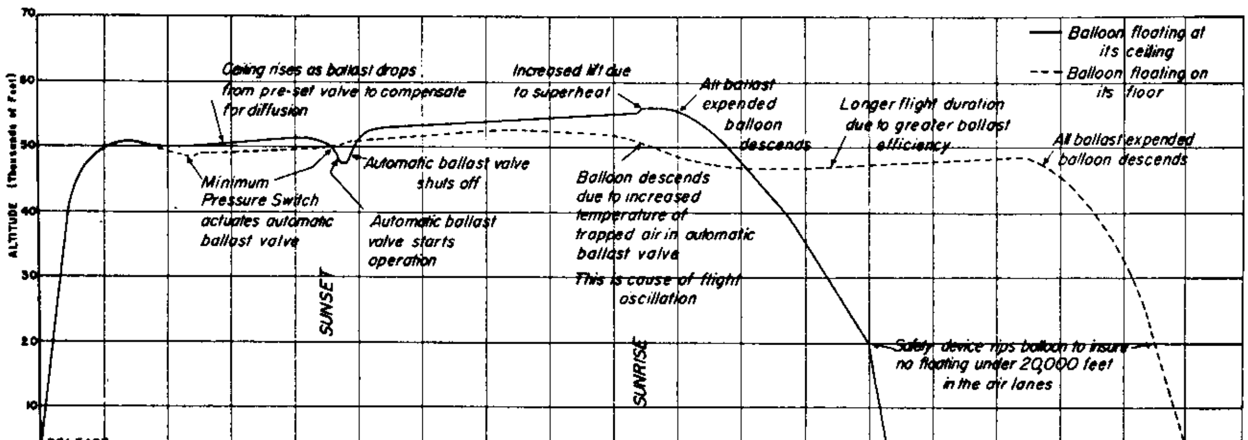

FIG. 6. Idealized time-altitude curves for various balloon-control systems.

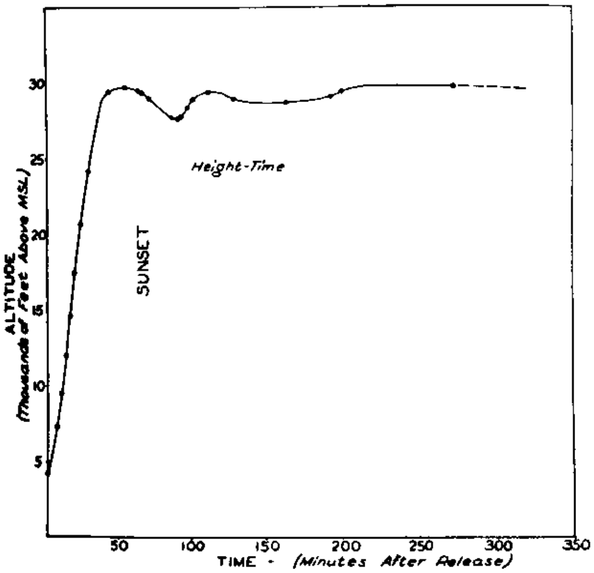

FIG. 7. Height-time curve of balloon Flight 17. Released at Alamogordo, New Mexico, on 9 September 1947 at 1647 MST (105th meridian). Recovered near Pratt, Kansas, 530 miles distant.

constant leakage held the balloon at 16,800 ± 700 ft for 7 hours. The duration of the flight was 9¼ hours. When the original 2700-gram ballast was expended, the balloon descended rapidly. Even had the automatic ballast valve been functioning, the constancy of altitude would have been the same. This seems to indicate that only a minimum of automatic control is needed, provided that diffusion losses are slightly overcompensated by a constant ballast leak.

Other flights also indicate the importance of a check valve in the balloon appendix to prevent dilution of the lifting gas with air. If this is not done, the altitude reached is far under the theoretical altitude determined by the displacement and gross load.

7. Control systems

Two systems of control are possible with the equipment as described. The balloon is controlled between an upper level (ceiling), where the full balloon buoyancy just equals the load, and a lower level (floor), below which the automatic ballast valve operates. Schematic curves for these two systems of control are shown in fig. 6.

In the first system of control the rate of static ballast leakage is greater than the diffusion loss of lift, and the balloon will stay at the ceiling. If it is displaced above the ceiling the buoyancy is insufficient to balance the load and it will descend again. Provided the rate of ballast discharge is greater than the rate of lift by loss of gas this ceiling will slowly rise by valving of gas, and as gas is lost by diffusion. The less the amount of gas the lower the pressure (higher ceiling) must be for the gas to fully distend the envelope. Unnecessary valving is undesirable and may, in part, be minimized by use of a restraining safety valve set in the appendix, which will allow some slight pressure to be carried in the balloon, preventing gas loss at the peaks of minor oscillations but still valving gas before the balloon ruptures due to too great an internal pressure.

In this system of control, the automatic valve is not sealed off until the balloon starts a descent due to cooling or other changes in lift, as when night falls. Upon descent the valve is activated and starts dropping ballast immediately; this continues until the balloon is no longer losing lift at a rate greater than the diffusion losses. The balloon will then rise above its former ceiling to a height determined by the weight of ballast dropped, and remain there as long as there is ballast to compensate for lift losses. Flight 17, reproduced in fig. 7, used a low-leakage balloon and is an actual case of ceiling control. It may be compared with the idealized time-altitude curves in fig. 6.

In the second system of control the static rate of leakage is less than the diffusion loss of lift. In this case the balloon will descend to the floor, where the automatic control operates and the balloon floats at an equilibrium altitude where the rate of ballast release exactly balances the rate of loss of lift. Floor control conserves ballast, since only that needed for altitude control is released. However, the altitude of the floor varies diurnally as the temperature of the entrapped air in the automatic ballast valve is affected by solar radiation. Two methods are being investigated to circumvent this undesirable feature. One is to

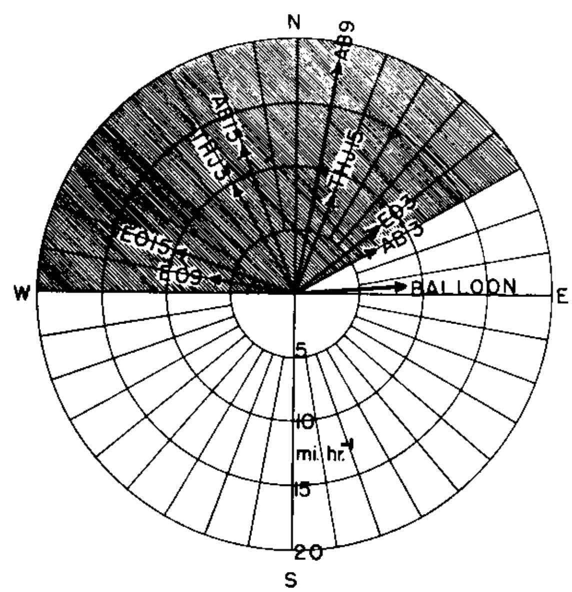

FIG. 8. Wind vectors at 16,000 feet for El Paso (EO), Albuquerque (AB), and Roswell (THJ), at 03^h, 09^h and 15^h (MST) on 7 July 1947, in connection with balloon Flight 11, mean motion of which is shown by the balloon vector. Cross-hatched sector contains all wind vectors at these three stations for the three observation hours and for the three levels, 14,000, 16,000, and 18,000 feet.

temperature-compensate the diaphragm, the other to insulate and shield the valve from radiation.

Using the ceiling-control system, flights of less than 24 hours not passing through sunset, may be held at ceiling by use of a nonextensible balloon and a simple fixed rate of leak to over-compensate diffusion losses. The constancy of level will be better the lower the diffusion and the lower, therefore, the rate of rise of the ceiling. The automatic control is needed for flights lasting through a period in which day changes to night.

8. Preliminary trajectory analysis of two constant-level balloon flights, 7 July 1947[7]

The most striking feature of the constant-level balloon flight (Flight 11, fig. 9) originating at Alamogordo Army Air Base at $05^{h}08^{m}$ MST[8] on 7 July 1947 is the disagreement between the actual trajectory and the trajectory that might have been estimated from routine upper-wind reports. In this connection the observations from the Weather Bureau stations at El Paso, Roswell, and Albuquerque have been examined, since the path of the balloon was contained within the triangle formed by these stations. Over El Paso, the wind direction at 16,000 ft (the approximate average altitude of the balloon during the greater part of the flight) was approximately SW at 03^{h}, ESE at 09^{h}, and ESE at 15^{h}. Over Roswell, the apparent average wind direction at 16,000 ft was S during this period. Over Albuquerque, which was considerably farther from the path of the balloon than the other two stations, the wind direction at 16,000 ft was variable between WSW and SSE during the interval from 03^{h} to 15^{h}. In contrast with these observations is the fact that the constant-level balloon floated in an essentially steady WSW current between 06^{h} and 09^{h}.

In fig. 8 the wind observations at 16,000 ft have been plotted for El Paso, Roswell, and Albuquerque for 03^{h}, 09^{h}, and 15^{h}. The wind directions at 14,000 ft, 16,000 ft, and 18,000 ft (only the intermediate level is shown in the figure) are all contained in the 150-degree sector between directions 90° and 240°; yet the mean motion of the balloon (approximately 265°) between $05^{h}48^{m}$ and $13^{h}11^{m}$ falls entirely outside this sector.

An indication that this local WSW current was of small depth is given by a special upper-wind observation made at White Sands at about 13^{h}. The observation in question recorded a wind direction of 250° at 16,000 ft, which is in excellent agreement with the first

[7] The authors are indebted to Prof. G. Emmons for contributing the major part of this section.

[8] Mountain Standard Time—105th meridian civil time. All further time references will be tacitly MST.

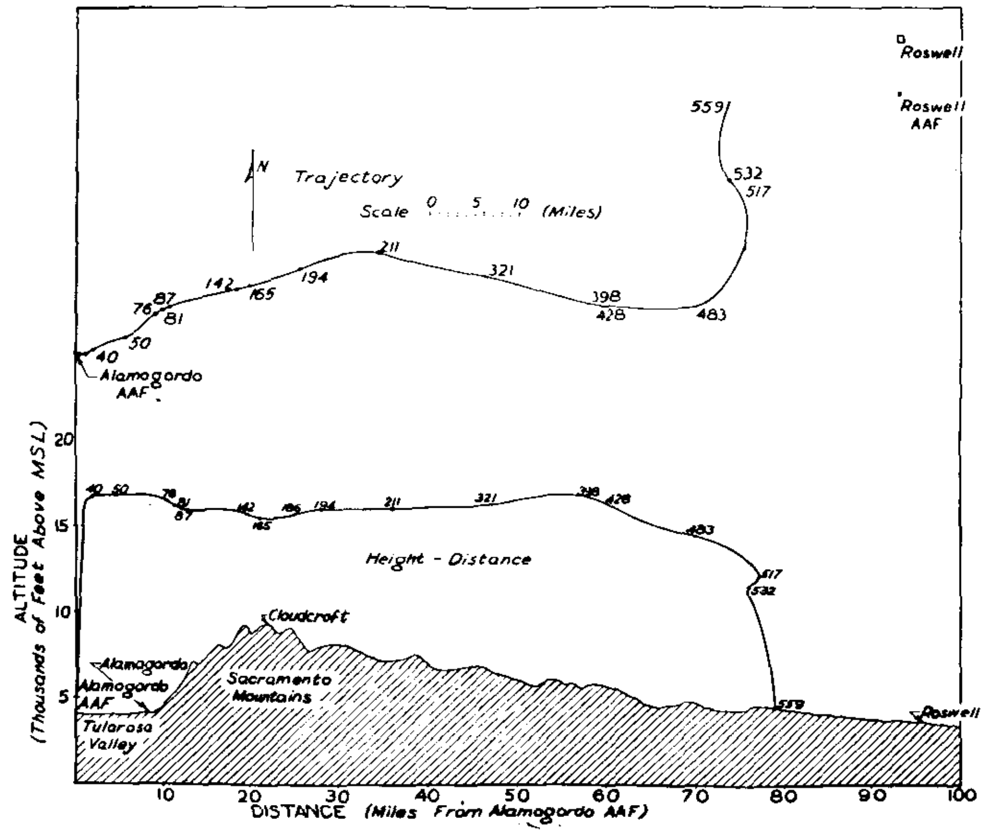

FIG. 9. Height-distance curve and planned trajectory of balloon Flight 11. Released at Alamogordo, New Mexico, 7 July 1947, at 0508 MST. (Numerals on curves indicate minutes after release.)

part of the trajectory of the constant-level balloon. The interesting fact about the White Sands observation is that *at all but one of the other reported altitudes* between the ground and 20,000 ft, the wind directions were from either the NE or SE quadrants.

The trajectory of the balloon curved slightly anticyclonically over the eastern slopes of the Sacramento Mountains. This characteristic is suggestive of the well-known deforming effect of a mountain range on an air current directed toward the axis of the range. In this case, however, the validity of invoking the aforementioned effect to explain the anticyclonic curvature, when the wind at levels below the mountain summits appears to have been blowing approximately parallel to the range, depends on assuming that the air currents parallel to the range themselves constitute a barrier deforming a higher current blowing in a different direction across the mountains. The sharp cyclonic bend that occurred after the balloon had come over relatively flat country occurred at the time that the balloon began its final descent and is due to the fact that the course of the balloon turned toward the north as a result of descent to levels where the wind had maintained a southerly direction throughout the day.

It is of interest to compare this flight with Flight 17 (fig. 10). It may be observed on fig. 10 that no deforming effect of the mountain barrier is apparent. This, however, is to be expected, as the altitude of the balloon above the mountain top is three times that of Flight 11, where this anticyclonic deformation of the trajectory was observed. The balloon was ultimately recovered from Croft, Kansas, a distance of 530 miles from the release point; on the basis of the observed wind speeds a 12-hour flight duration is estimated.

9. Conclusion

Within the coming year it is hoped that a number of meteorological investigations may be attempted, utilizing constant-level balloons. Release of three or more from a single point to float at the same level, release at a number of points to obtain a synoptic presentation of the trajectories in a chosen level, and the dropping of radiosondes from balloons are some of the operations to be attempted. Efforts will be made to simplify the arrangement so that a constant-level flight may be made in a routine fashion and at no greater cost than the ordinary radiosonde flight.

REFERENCE

Clarke, E. T., and S. A. Korff, 1941: The radiosonde: the stratosphere laboratory. *J. Franklin Inst.*, 232, 217–355.

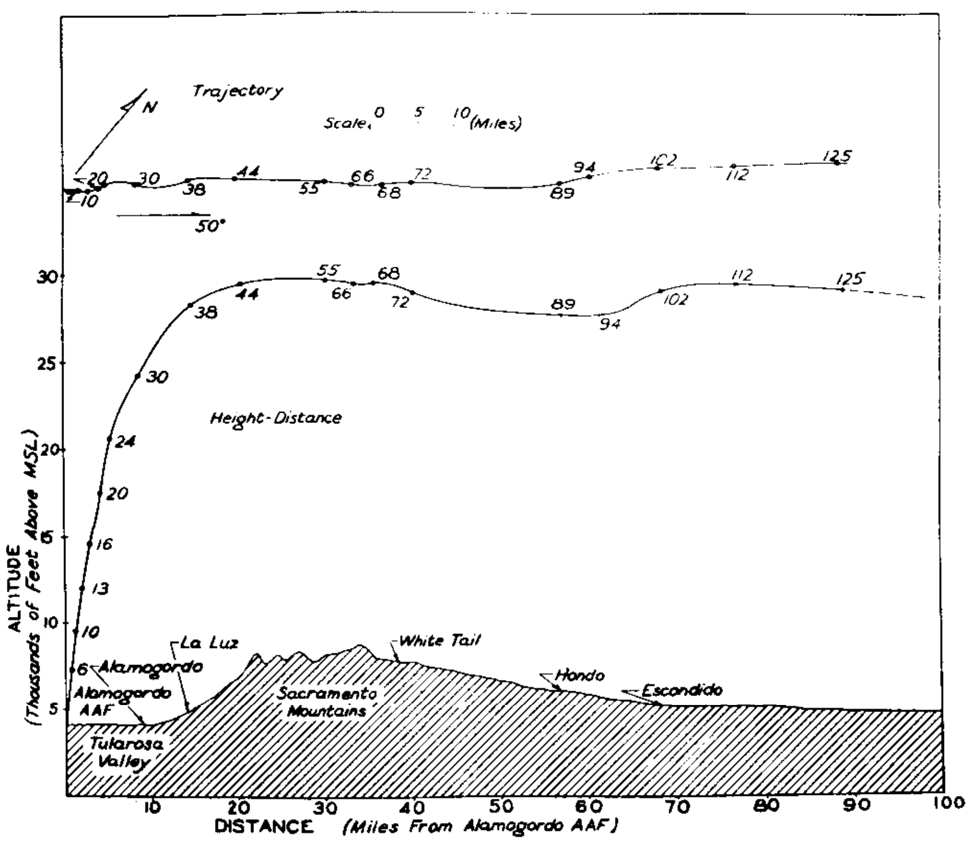

FIG. 10. Height-distance curve and planned trajectory of balloon Flight 17. Released at Alamogordo, New Mexico, 9 September 1947, at 1647 MST. First 125 minutes only are shown. (Numerals on curves indicate minutes after release.)

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New York University
Progress Report No. 6
Constant Level Balloon
Section II
June 1947

PROGRESS REPORT #6

Covering Period from May 1, 1947 to
May 31, 1947

CONSTANT LEVEL BALLOON

Section II

Research Division, Project No. 93

Prepared in Accordance with Provisions of Contract
W28-099 ac-241, between
Watson Laboratories, Red Bank, New Jersey
and
New York University

Prepared by Charles S. Schneider

Approved by Professor Athelstan F. Spilhaus
Director of Research

Research Division
College of Engineering
June, 1947

I. The following new men were employed on the Balloon Project during May:

Name	Duties	Qualifications
J. Richard Smith	Meteorologist (full time)	Former Weather Bureau and Army forecaster. Taught weather equipment at New York University, M.S. in Physics-Meteorology, NYU.
William O. Davis	Balloon Performance Analyst (part time)	B.A. Physics, New York University. Former AAF pilot. Graduate student in Physics.
Fred Barker (rehired)	Equipment Construction (part time)	Undergraduate Aeronautical Engineering Student.

II. The following administrative action was taken during the month of May:

A bid was obtained from Skinner, Cook, & Babcock, Contractors, at 60 E. 42d Street, New York City, for the erection of a prefabricated building for the Balloon Project. The quotation of $4,000 was forwarded to Watson Laboratories.

Correspondence during this period was as follows:

Date of Correspondence	Address	Abstract	Answer
5/1/47	WIRE Dr. Frank Myers Lehigh University Bethlehem, Pa.	Use of football bield requested for balloon launching on 6 May.	Granted.
5/5/47	WIRE Same	Bad weather postponed flight until 9 May.	None needed.
5/6/47	Kollsman Instrument Div. Square D Co. Elmhurst, L.I. Att: Paul Goudy	Request for quotation on diaphragm seal-off for dribbler and for increased quantity of modified dribblers.	Furnished.

5/7/57	WIRE Barney Frank Hightstown, N.J.	Samples of parachute shroud lines requested.	Furnished.
5/6/47	General Mills Minneapolis, Minn. Att: Mr. O. C. Winzen	Request for quotation on sample balloons shown to C.B. Moore on visit.	Awaiting Navy clearance.
5/13/47	Dewey & Almy Chem. Co. Cambridge, Mass. Att: Mr. Isom	Request delivery date on 1000 gm balloons.	Given.
5/14/47	Mr. G.P. Clare 4719 W. Sunnyside Ave. Chicago, 30, Ill.	Request for information and catalogues on rotary switches.	Furnished.
5/14/47	Goodyear Tire & Rubber Akron, Ohio Att: Leonard M. Harb	Delaying action in Goodyear's quotation for balloons.	
5/15/47	Office of the Secretary Fort Worth Sub-Committee on Air Space Civil Aeronautics Authority, (4th Region) Fort Worth, Texas	Request clearance for flight of Balloons from Alamogordo.	Given.
5/27/47	General Mills Minneapolis, Minn. Att: Mr. O.C. Winzen	Repeat request for quotation on plastic balloons.	Awaiting Navy clearance.

IV. Conferences

The following conferences were held during the month of May:

Date	People Present	Where Held	Discussed	Conclusions
5/1/47	O. C. Winzen of General Mills	General Mills Minneapolis, Minn.	Manufacture of balloons by General Mills for this project.	Obtain Navy clearance General Mills balloons look good for our work.
5/8/47	Dr. Peoples, Mr. Ireland, of Watson Laboratories. C.S. Schneider, C.B. Moore	Watson Laboratories Red Bank, N.J.	Bethlehem flight for May 9.	Final details.
5/10/47	Same	Same	New flights at Alamogordo, N.M., where lower winds can be found.	Set up trip to Alamogordo for May 29.
5/13/47	Paul Goudy of Kollsman Instrument C.B. Moore	Kollsman Instrument Div. Square D Co. Elmhurst, L.I.,N.Y.	New dribbler design.	
5/14/47	Representative of Vulcan Proofing Co. C.S. Schneider, C.B. Moore	Vulcan Proofing Co. Brooklyn, N.Y.	Testing of balloon fabrics and films.	Vulcan proofing would make tests.
5/22/47	Dr. Peoples, Messrs: A.H.Mears, John Alden, Charles Ireland, C.S.Schneider, C.B. Moore	Watson Laboratories, Red Bank, N.J.	Final arrangements for Alamogordo trip.	

III C 1. General Work Accomplished

A conference was held on May 1 at Minneapolis with Mr. O. C. Winzen of General Mills concerning the manufacture of balloons by General Mills for this project. At the present time this company cannot supply us with balloons until Navy clearance is obtained, but it is hoped that arrangements can be completed in the near future. The type of balloons manufactured by General Mills seems to be well suited to the needs of this project.

On May 8 a trip was made to Lehigh University, Bethlehem, Pa., to fly a cluster of meteorological balloons carrying Watson Laboratories equipment. Winds developed during launching and the balloons escaped when the restraining lines snapped under the strain, carrying balloons aloft without payload.

As a result of this incident, two conslusions were drawn: first, that a new launching technique was needed; second, that another launching site must be selected offering consistently calm winds during launching. It was decided to make the next flights at Alamogordo, New Mexico, early in June.

On May 14 a conference was held at the Vulcan Proofing Co., in Brooklyn, N.Y. to discuss the possibility of this company testing various types of fabric and film used in the manufacture of balloons. It was agreed that the company would make the desired tests when ordered by us.

The high point of the month's activities was the departure for Alamogordo on May 31, and the balance of the month was spent in the preparation of equipment for the flights to be made there. Departure was made from Olmstead Field, Middletown, Pa. in a C-47 furnished by the Watson Laboratories.

2. Specific Problems

In general, problems remain the same as those discussed in the previous report, namely: the determination of the relative merits of various balloon films and fabrics available; the analysis of the altitude control devices to be used; and the flight testing of the equipment to be used in preliminary work. All of these problems now await further flights and delivery of equipment ordered before solution can be attempted.

3. Limitations.

The greatest hindering factor in the progress of work is the lack of available space. The prefabricated building to be furnished by the government under the terms of the contract is now more urgently needed than before, due to the hiring of more personnel. The joint laboratory and office which this project shares with another is highly inadequate for six men of theirs and eleven of ours -- a total of 17 men in a space approximately 15x15 feet.

d. Methods of Attack

Until plastic balloons can be obtained, we will continue to fly clusters of meteorological balloons.

e. Apparatus and Equipment

The only substantial change in equipment during the period covered by this report, other than general strengthening of flying lines, is the addition of a new main sand ballast dropping device to the equipment train of the flights to be made at Alamogordo.

The device consists of a nest of eight plastic tubes each filled with dry sand and sealed on the bottom with a sturdy paper membrane. At the bottom of each tube, resting against the membrane, is a small detonating squib of sufficient force to rupture the paper and permit the sand to fall. Each squib is connected to a different lead on the baro-switch of a radio-sonde modulator, so that a predetermined weight of sand may be released at eight predetermined altitudes. A small wire "shelf" is placed over the commutator of the modulator in such a way that the pin arm is lifted clear of the contacts during ascent and permitted to drop into place at an altitude above that of the highest firing contact. This is designed to prevent the firing of squibs and consequent dropping of ballast during ascent.

f. Conclusions and Recommendations

It is felt that the use of freely extensible meteorological balloons is unsatisfactory for any final solution of our problem because of their inherent instability and the rapid deterioration of neoprene rubber under the rays of the sun. It is felt that cluster flights of these balloons are a purely stop-gap method of floating Watson Laboratories equipment until plastic non-extensible balloons can be obtained and tested.

The need for greater work space is becoming increasingly urgent as new personnel are added to the project and the extent of the work grows.

It is believed that with present equipment the Alamogordo, New Mexico, area is the most suitable available for launching purposes, since calm winds are consistently present at dawn, and there are a minimum of clouds to impair ground observation of the balloons in flight.

Future Work

It is hoped that in the immediate future satisfactory techniques for the launching and floating of cluster flights may be developed under optimum conditions, and tests made on small plastic balloons to be furnished by H.A. Smith, Coatings, Inc., of Mamaroneck, New York.

Arrangements have been completed with the Vulcan Proofing Co. of Brooklyn, N.Y. to test various balloon fabrics and films available. These tests will probably be conducted in the near future.

As soon as arrangements can be completed to obtain Navy clearance we plan to obtain non-extensible balloons from General Mills in sufficient quantity to make flight tests and commence work on the ultimate objective of this project.

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New York University
Special Report No. 1
Constant Level Balloon
May 1947

See also
Weaver Attachment 25

SPECIAL REPORT #1

Covering Period from January 1, 1947
to April 30, 1947

CONSTANT LEVEL BALLOON

Research Division, Project No. 93

Prepared in Accordance with Provisions of Contract
W28-099 ac-241, between
Watson Laboratories, Red Bank, New Jersey
and
New York University

Prepared by: Charles S. Schneider
Charles S. Schneider
Assistant Project Director

Approved by: Renato Contini
Renato Contini
Acting Director of Research

Research Division
College of Engineering
May, 1947

ABSTRACT

A preliminary survey was made of the problem. Specifications were drawn up for the equipment needed and manufacturers were contacted to construct experimental balloons and altitude controls.

A balloon crew was assembled.

While awaiting delivery on the NYU designed equipment, clusters of meteorological balloons have been flown for experience and as a stop-gap method of carrying a payload to altitude. In addition, two salvaged, racing-type, man-carrying balloons of 35,000 cubic foot size have been procured and are being prepared for flight. Two 19,000 cubic foot Japanese balloons have been made available by the Navy.

Preliminary calculations have been made on balloon buoyancies and families of curves plotting altitude vs. lift for various balloon sizes have been prepared for planning and flight purposes.

Civil Aeronautics Authority has given clearance for flight of large balloons form Lakehurst, New Jersey, and Bethlehem, Pennsylvania, with certain restrictions.

REPORT

I. The personnel working on this project consists of the following full-time employees:

Name	Duties	Qualifications
Charles S. Schneider	Asst. Proj. Director	Former weather equipment officer, Army Air Forces doing similar work during the war. Elec. Engineering, Brooklyn Polytechnic & NYU
Charles B. Moore Jr.	Research Engineer	Former weather equipment officer, Army Air Forces doing similar work during the war. Graduate of Georgia School of Technology in Chemical Engineering.
Richard Hassard	Chief of Flight Detail	Former Signal Corpos Officer, Elec. Engineering at NYU.
Murry Hackman	In charge of the Electronic Weather Equipment.	Former weather equipment Technician, Degree in Mathematics and Statistics City College of New York.

In addition to the above full-time employees, the following part-time personnel are now working on the project:

Name	Duties	Qualifications
Henry Kammenzind	Computations & Equipment Construction	Undergraduate Elec. Engineering Student.
Ralph Morrell	Equipment Construction	Undergraduate Admin. Engineering Student.
James Smith	Weather Observer and Draftsman	Former Weather Observer in Army and Undergraduate Engineering Student.
William Kneer	Machinist	Undergraduate Engineering Student.

The following personnel were hired but later resigned:

Name	Duties	Qualifications
Robert Wisnieff	Equipment Construction	Undergraduate Physicist Student.
Robert Ferris	Equipment Construction	Undergraduate Physics Student.
Fred Barker	Equipment Construction	Undergraduate Aeronautics Engineering Student.

II. The following administrative action has been taken in connection with this contract:

Personnel

1. The assignment of Charles S. Schneider to act as Assistant Project Director.

2. The employment of Charles B. Moore Jr. of Georgia Tech. as a Research Assistant with duties as Engineer.

3. Murry Hackman was engaged to take charge of the Electronic weather equipment due to his past experience as a weather equipment technician and as an instructor of the AAF classes in the maintenance of radiosonde receptor AN/FMQ-1 and radio directional finder SCR-658 at Chanute Field, Illinois.

4. Richard Hassard, a former Signal Corps Officer was hired because of his general knowledge of electrical and radio circuits to handle the construction of special flight equipment.

Equipment

5. As New York University did not possess all the necessary equipment a list of equipment was prepared and submitted to the Government with the request that this equipment be loaned or furnished

by the government. To date most of this equipment has been received with the exception of the AN/FMQ-1, SCR-658 and the prefabricated buildings needed for office and storage space.

6. The list of equipment that was submitted to the government consisted of the major items that were necessary. However, because many small hand tools and radio parts and other equipment were needed periodically a petty cash fund of $100 was set up to facilitate purchase of small items. A further request has been submitted to the Chancellor of the University requesting that this petty cash be increased to $200 and that a travel fund of $100 be established.

Housing

7. The existing inflation shelter at the school for the Meteorological Department's use was not adequate to handle the large diameter plastic balloons that we plan to use. Therefore a request was submitted and approved by the Contracting Officer for the construction of a 27 ft. cube inflation shelter on the campus of New York University. Due to restrictions placed on us by the Air Space Sub-Committee of the Civil Aeronautics Authority, New York Office, it has since been decided not to erect this inflation shelter in the New York area, but rather to use existing facilities at Lakehurst, New Jersey or Olmstead Field, Middletown, New Jersey.

Sub-Contracts

8. Permission was secured from the Contracting Officer of the Watson Laboratories to place two sub-contracts. One was for the fabrication of plastic balloons and was placed with Harold A. Smith Inc., of Mamaroneck, New York. This sub-contract amounted to $7,565. The second sub-contract was placed with Kollsman Instrument Division of

Square D Incorporated at Elmhurst, Long Island, New York. This sub-contract was for the construction of model altitude controls and amounted to $7,446.

Correspondence written during this period is as follows:

Date of Corres-pondence	Address	Abstract	Answer
11/7/46	Plax Corp Hartford, Conn. Att: Mr. Griffith	Forwarding P.O.#5983 & Requesting price quotation and delivery schedule for 4 diff. thicknesses of 36" wide polyethylene sheet (.001" .00225" .004" and .008".	Not furnished.
11/7/46	Visking Corp. Chicago, Ill. Mr. Cahn	Request to know what maximum width Poly-ethylene could be supplied in, and what the cost and delivery date would be.	
12/4/46	Visking Corp. Chicago, Ill. E. B. Cahn	Advising interest in securing 300 ft. of 72" circumference poly-ethylene tubing re-quest information on thickness and price.	72" circumference Polythylene tube could be furnished. Request to know quantity and thick-ness .002 mil thick $1.40/lb. estimate and would need 19 lbs.
12/10/46	Dewey & Almy Chem. Co. Cambridge, Mass. Att: Mr. Langley W. Isom	Acknowledging receipt of material used by Mr. Isom in his con-stant level balloon work. Also advising that order for single and double neck 1000 gram balloons had been placed.	None required.

12/16/46	Celanese Celluloid Corp. 180 Madison Avenue New York, N. Y.	Advising this company of our desire to fabricate a balloon from plastic film and our interest in ethyl cellulose as a possible plastic film to be used for this construction. Request that literature be supplied showing low temperature characteristics, tensile strength, etc.	Advising they do not believe ethyl cellulose would work secondly that they do not make film only molding powder - no literature available.
12/17/46	Nixon Nitrogen Works Nixon, New Jersey	Same request made of this company as with Celanese Celluloid Corp.	Advising they only make molding powder.
12/17/46	Plax Corp. Hartford, Conn. Att: Mr. Griffith	Advising that E. L. Cournand Co., recommended by Plax, had declined the contract for fabrication of balloons. That Unexcelled Chem. Corp. of New Brunswick had agreed to this fabrication and supplied the necessary shipping address for the polyethylene.	None required.
12/17/46	Dewey & Almy Chem. Co. Cambridge, Mass. Att: Mr. Isom	Acknowledging receipt of single and double neck balloons. Double neck balloons were received with a single neck plus a nub on the top of the balloon. Request to know whether shipment was in error and if so what disposition to be made.	Advising that nub must be cut with scissors in order to get double neck.
12/17/46	Dow Chem. Co. Midland, Mich.	Same request made of this company as that made with Celanese Celluloid Corp.	Not received.

12/24/46	Unexcelled Chem. Corp. Harold A. Smith	Advising the Plax Corp. had been supplied with his shipping address and also requesting his technical advice on the feasability of using a 72" wide strip of polyethylene, 2 mil. thickness that Visking Corp. of Chicago could supply.	Advising that .002 mil thickness too thin. Suggested endeavoring to obtain 72" width in .006 mil.
1/3/47	Harold A. Smith	Acknowledge receipt of letter of December 26th containing estimated cost of fabrication of balloon. Advising that the bid could not be accepted on a cost plus basis. Requesting that their quote be resubmitted.	New quotation furnished.
1/3/47	Visking Corp. Chicago, Ill. Att: J. L. Lane	Advising that fabrication of balloons at a 2 mil. thickness polyethylene film would be extremely difficult to handle. Request made that information be supplied on a 72" circumference film 4-6 mils in thickness.	Advising that they only have .004 and .006 15 18" flat width. The 36" width request could be made but price would be prohibitive.
1/8/47	Watson Laboratories Red Bank, N. J. Mr. A. H. Mears	Advising need of radiosonde receptor SCR658 by NYU plus power units and technical publications.	Advising part shipment would be made Feb. 13th.
1/8/47	Watson Laboratories Red Bank, N. J. Mr. A. H. Mears	Returning list of equipment to the government loaned or government furnished with request that certain corrections, additions and deletions be made.	Advising government records changed and that catalogues will be sent under separate cover.

1/14/47	Bland Charnas Inc. Yonkers, N. Y.	Requesting to know whether this company would consider fabrication of 15 ft. diameter plastic balloon.	Advising that they could not assist us in fabrication.
1/21/47	Shellmar Projects Corp. Mt. Vernon, Ohio	Request that they quote on delivery and cost of fabrication of 10 ea.15 ft. balloons. Five to be fabricated from Saran (Type M.00225" thick and 5 from polyethylene made from PM-1.004" thick.	Advising plant could not cope with problem at this time.
1/21/47	Milprint Inc. Milwaukee, Wisc. Mr. Paul B. Hultkrans	Same request as letter to Shellmar 1/21/47.	Verbally informed. Not interested.
1/21/47	Rowe Packaging Co. Ltd. Toronto, Canada	Same request as letter to Shellmar 1/21/47.	Wish to make model and submit same before quoting. Never heard anything.
1/21/47	Western Products Inc. Newark, Ohio	Same request as letter to Shellmar 1/21/47.	Acknowledged receipt of letter and advising quotation would follow. Did not arrive.
1/23/47	Kennedy Car Liner & Bag Co., Inc. Shelbyville, Ind.	Same request as letter to Shellmar 1/21/47.	Verbally informed. Not interested.
1/23/47	Unexcelled Chem. Corp. Harold A. Smith	Request for quote on 15-15 ft. diameter balloons and 6-3 ft. diameter balloons to be fabricated from various thicknesses of Saran and Polyethylene.	New quotation furnished.
1/23/47	Watson Laboratories Red Bank, N. J. Mr. A. H. Mears	Advising that tool equipment TE-50A was short a 6" ruler a pr. of tweezers, and a socket wrench. No request for replacement for these items made.	None required.

1/28/47	Kollsman Instrument Co. Elmhurst, L. I. Att: Paul Goudy	Request for quotation of 3 ea. of the following altitude control equipment: 1. Motor switched modulators. 2. Elec. controlled dribblers. 3. Mech. controlled dribblers.	Quotation supplied.
2/3/47	Contracting Officer Watson Laboratories Red Bank, New Jersey	Forwarding quote from Unexcelled & requesting approval.	Not approved.
2/7/47	Watson Laboratories Red Bank, New Jersey Att: Mr. D. Rigney	Requesting permission to build a 27 cubic foot inflation shelter.	Permission granted.
2/10/47	Contracting Officer Watson Laboratories Red Bank, New Jersey	Forwarding quotation received from Kollsman Instrument Co. for the necessary control devices for the constant level balloon.	Permission granted to place subcontrac
2/11/47	Patterson Bros. New York City Att: Mr. H. Carey	Advising that one Ungar electric soldering pencil is being returned under separate cover as it was received in unusable condition. Request for replacement made. Quotation enclosed.	Replacement made.
2/18/47	Contracting Officer Watson Laboratories Red Bank, N. J.	Requesting permission to place subcontract with Unexcelled Chem. Corp. for the fabrication of balloons.	Permission withheld.
2/24/47	General Mills Minneapolis, Minn. Mr. O. C. Winzen	Request that quotation be supplied for the fabrication of 15-15 ft. diameter balloons and 6-3 ft. diameter balloons made of various thicknesses of polyethylene and Saran.	Declining to quote until after conference with NYU representatives.

2/24/47	Bland Charnas Co. Inc. New York City	Same request as letter to General Mills 2/24/47.	No reply received.
2/24/47	Leonard M. Harb Goodyear Tire & Rubber Akron, Ohio	Same request as letter to General Mills 2/24/47.	Quotation supplied 15 April 1947.
3/6/47	Watson Laboratories Red Bank, N. J. Mr. Brophy	Forwarding copy of letter of request that had been sent to Mr. H. A. Smith for the fabrication of balloons.	No answer received.
3/7/47	Contracting Officer Watson Laboratories Red Bank, N. J.	Advising that Unexcelled Chem. Corp. did not wish to proceed with the contract and that instead H. A. Smith of Mamaroneck, N. Y. was willing to undertake the fabrication. Quotation from Mr. Smith enclosed. Request that approval be granted.	Permission granted.
3/7/47	Goodyear Tire & Rubber Akron, Ohio Mr. L. M. Harb	Request a quote on the fabrication of 5 ea. balloons made from Nylon covered with suitable neoprene and 5 ea. balloons made from fortisan covered in a similar fashion. Advising that any recommendations concerning balloon fabrics would be appreciated.	Quotation supplied 15 April 1947.
3/7/47	Seyfang Laboratories 1300 Mediterranean Ave. Atlantic City, N. J.	Same request as letter to General Mills 2/24.	Advised interest. Ask for conference.
3/7/47	Unexcelled Chem. Corp. New Brunswick, N. J.	Requesting that polyethylene film that had been shipped to them from Plax Corp. be returned to NYU.	No action taken.
3/7/47	Plax Corp. Hartford, Conn. Mr. R. E. Ames	Request that shipping address for polyethylene film be changed from Unexcelled Chem. Corp., New Brunswick, N.J. to H. A. Smith, 490 Bleecker Ave., Mamaroneck, N.Y.	No answer required

3/19/47	Unexcelled Chem. Corp. New Brunswick, N. J. Att: Mr. Tegen	Confirming telephone conversation in which authorization was given to ship polyethylene film to NYU and advising once again of correct shipping address.	Film shipped. Quotation supplied.
3/21/47	Manne-Knollton Insul. Co., N. Y. C.	Requesting quote and delivery date on fibre screws 1¼" long, fillister head and 8-32 thread.	Quotation supplied.
3/24/47	General Mills Minneapolis, Minn. Mr. O. C. Winzen	Acknowledge letter of 3/11 and advising that our representatives would be pleased to discuss construction details of the balloons.	Asked for conference in April.
3/24/47	Mr. R. S. Hassard 5 Hollywood Ave. Tuckahoe, N. Y.	Advising him of possibility of full-time position in Research Div. of NYU. Requesting that he make appointment for interview.	Hassard employed.
3/25/47	Mr. George E. Weidner Engineer Board Barrage Balloon Branch Ft. Belvoir, Va.	Requesting permission for NYU representatives to visit with him to discuss constant level balloons and safety valves and control devices.	Invited to visit Mr. Weidner.
3/27/47	H. A. Smith Mamaroneck, N. Y.	Requesting quote on valves.	Supplied
3/29/47	H. A. Smith Mamaroneck, N. Y.	Request for quote on balloons fabricated from nylon and fortisan film coated with butyl rubber.	Not received.
3/29/47	Seyfange Laboratories 1300 Mediterranean Ave. Atlantic City, N. J.	Requesting quote on 3 sets of stabalizer fins.	Received.

3/31/47	J. R. Garvin Douglas Leigh Sky Advertising Co. Lakehurst, N. J.	Requesting quote for the 80,000 cu. ft. balloons that this company received from surplus.	Acknowledged. Asked for definite express ion of interest.
3/31/47	Seyfang Laboratories 1300 Mediterranean Ave. Atlantic City, N. J.	Requesting quote on one to five each 15 ft. diameter balloons made of 3 oz. silk cloth coated with neoprene and 2 each 3 ft. diameter balloons made from the same material.	Furnished.
4/1/47	Mr. J. Boyle Air Cruisers Inc. Clifton, N. J.	Requesting quote on 25-15 ft. diameter balloons and 10-3 ft. diameter balloons made from polyethylene .004" polyethylene .008" saran .00225" and a fortisan fabric coated with butyl rubber and from nylon film.	Quote furnished on nylon fabric coated with butyl rubber. Interested but want cost plus basis.
4/1/47	Molded Latex Products Inc. Paterson, N. J.	Identical letter as above request to Air Cruisers Inc.	Furnished.
4/8/47	WIRE H. J. Brailsford & Co. Inc. Rye, N. Y.	Requesting price and delivery date of 3 volt price type relays.	
4/8/47	Capt. Albert C. Trakowski Watson Laboratories Red Bank, N. J.	Forwarding minutes of Air Space Sub-Committee Meeting.	None required.
4/8/47	General Mills Minneapolis, Minn. Mr. O. C. Winzen	Acknowledging receipt of March 31st letter and notifying this company that our representatives would be pleased to come at their convenience.	April date set.
4/10/47	WIRE H. G. Brailsford Rye, N. Y.	Requesting to know how relays ordered were shipped.	Answered.
4/10/47	WIRE Lehigh University Bethlehem, Pa. Prof. Frank Myers	Requesting permission to make balloon release from Lehigh University on 15 April.	Given.

4/10/47	WIRE Seyfang Laboratories 1300 Mediterranean Ave. Atlantic City, N. J.	Requesting to know whether April 17th or 18th would be satisfactory to Mr. Frank C. Seyfang to meet NYU representatives to inspect 80,000 cu. ft. and 2-35,000 cu. ft. in Heightstown, N. J.	Date Given.
4/11/47	WIRE Dewey & Almy Cambridge, Mass. Mr. W. L. Dawbarn	Advising that single neck N1000 gram balloons should be furnished on our order 148-48.	None needed.
4/14/47	WIRE Frank Seyfang Seyfang Laboratories Atlantic City, N. J.	Advising NYU representative could not keep engagement for April 17th to inspect balloons and requesting that next best suitable date be furnished.	Furnished.
4/15/47	WIRE Mr. Barney Frank 27 Rochdale Ave. Roosevelt City, N. J.	Advising NYU still interested in purchase of balloons. Requesting that inspection date be changed from 17 Apr. to 23 Apr.	Satisfactory
4/17/47	WIRE Lehigh University Bethlehem, Pa.	Advising time of arrival at Lehigh to release balloons.	None needed.
4/17/47	N. Y. Sub-Committee on Air Space 385 Madison Ave., NYC Att: C. J. Stock	Advising that discrepancies observed in minutes of CAA meeting and requesting that conditions for more suitable flights be granted.	Request refused.
4/21/47	WIRE General Mills Minneaplis, Minn. Mr. O. C. Winzen	Advising that NYU representatives would make definite date for arrival later in week.	

4/21/47	WIRE Barney Frank 27 Rochdale Ave. Roosevelt City, N. J.	Confirming date of Apr. 23 for date inspection of balloons.	None needed.
4/21/47	Seyfang Laboratories Atlantic City, N. J.	Confirming date of 23 Apr. for date inspection of balloons.	Answered.
4/23/47	Kollsman Instrument Division 80-08 45th Avenue Elmhurst, L. I.	Changing details in altitude control purchase order.	None needed.
4/28/47	WIRE Seyfang Laboratories Atlantic City, N. J.	Advising that 2 - 35,000 cu. ft. balloons were purchased from Barney Frank and that these balloons were being shipped to him for repair.	Acknowledged.
4/28/47	Barney Frank 27 Rochdale Ave. Roosevelt City, N. J.	Advising that University would buy 2 - 35,000 cu. ft. balloons and that these balloons should be shipped to Seyfang Laboratories.	Acknowledged.

IV. Conferences

Preliminary conferences were held with plastic packaging companies. However, as trained personnel were not always available at the time of these conferences with the various companies it was necessary to write followup letters. Reference to these letters can be found under communications of this report.

In addition to these preliminary conferences regarding plastics the following conferences were also held:

Date	People Present	Where Held	Discussed	Conclusions
2/11/47	Dr. J. Peoples, C. Ireland, D. Rigney, Capt. Trakowski, Hackman, Moore, Schneider	Watson Laboratories Red Bank, N. J.	Government furnished equipment.	Equipment would be expedited by Watson.
2/21/47	R. Brophy, Dr. J. Peoples, Capt. Trakowski, D. Rigney, Schneider, Moore	Watson Laboratories Red Bank, N. J.	Placement of sub-contracts for balloons with H. A. Smith, Inc.	NYU should visit Goodyear before placing contract.
2/25/47	Lt. Comdr. Harrison, Dr. Peoples, Schneider, Moore, Hackman	Lakehurst Naval Air Station Lakehurst, N. J.	Jap Balloons.	Jap balloons were available for projecture.
2/27/47	J. Sturtevant, L. Harb, Schneider, Moore	Goodyear Tire & Rubber Co. Akron, Ohio	Fabrication of large balloons	Goodyear was interested and would prepare a quote.
3/3/47	Dr. Peoples, D. Rigney, Moore, Schneider	Watson Laboratories Red Bank, N. J.	Placement of sub-contracts for balloons and altitude controls.	Permission granted to place sub-contract.
3/21/47	Mr. Hagen, Dr. Prendergast, Moore	Molded Latex Paterson, N. J.	Fabrication of large balloons.	Await preparation of a quote.

3/25/47	Lt. Gunther, Comdr. Harrison, C. Ireland, Moore	Lakehurst Air Naval Station Lakehurst, N. J.	Use of Lakehurst as a launching site.	Lakehurst would be available to Watson.
3/26/47	F. Seyfang, Mrs. F. Seyfang, Moore, Schneider	Atlantic City, N. J. Seyfang Laboratories	Fabrication of large balloons.	A quotation would be prepared.
4/4/47	Dr. Peoples, D. Rigney, Moore, Schneider	Watson Laboratories Red Bank, N. J.	1st Cluster Flight	Prepare for Second Flight
4/11/47	R. Brophy, Mr. Cambridge R. Contini, M. Giannini Schneider, Moore	New York University	Contract Administration	Housing would be provided by govt.
4/30/47	P. Goudy, Moore	Kollsman Instrument Co. Elmhurst, L. I.	Ballast valve construction.	Change indetails.

During the period covered by this report, Messrs. Moore and Schneider made repeated trips to Kollsman Instrument Co. and discussed the fabrication of the modulators and other equipment that Kollsman was designing for our use. These meetings have not been considered conferences but for the benefit of this report the same individuals were always present, Messrs. Schneider and Moore of New York University and Paul Goudy, Engineer fo r Kollsman Instrument Co. The material discussed was methods of improving the construction of the modulators and other equipment.

III C 1. General Work Accomplished.

The period was spent in preparatory work which consisted of the following phases:

Phase 1. The designing of a balloon and of altitude controls to be used as tentative solutions to the main problem.

2. The contacting of plastic film fabricators to obtain several sources of supply for large non-extensible balloons. To date, one sub-contract has been let for 15 ft. diameter balloons.

3. The contacting of an instrument company which would construct the altitude control devices. A subcontract has also been let for altitude controls.

4. The designing of a large balloon inflation shelter at N. Y. U. Materials have been procured for it. Due to change in plans the shelter will not be built at N. Y. U. therefore the materials are being held for the government until termination of contract.

5. The repairing and testing of the radiosonde receptor in Department of Meteorology for preliminary flights pending the arrival of Government-loaned equipment.

6. The preliminary flights with clusters of Meteorological balloons as stop-gap methods to attempt constant level balloon flights while awaiting the delivery of N. Y. U. designed equipment.

7. The making of preliminary calculations and requirements on constant level balloon performance.

2. Specific Problems.

Yet to be determined is the relative merits of various balloon films and fabrics available. This is to be handled by test work done by the General Mills and perhaps by the Bureau of Standards in Washington.

The altitude control devices need to be analyzed for determination of optimum settings for initial action and rates of release of the ballast. This problem is awaiting some flights before a full scale, mathematical study is undertaken.

The main problem is the flight testing of the equipment planned as a tentative solution to the desired flight path. This awaits receipt of some large lightweight balloon envelopes and more of the altitude controls.

3. Limitations.

More work would have been accomplished had the equipment to be furnished by the Government arrived. The prefabricated building that is to be supplied by the Government according to the contract is urgently needed, as there is no housing available for the project at N. Y. U. The project personnel has been using work benches occupied by other projects. The project has been using the office space of another research group. This has not been satisfactory as six of their men and four of ours attempt to work in a joint laboratory and office 15 x 15.

Restriction on the project is the Civil Aeronautics Authority requirement that balloon flights be made only on days that are cloudless up to 20,000 feet. This is difficult to meet in the eastern United States but appears less difficult in the New Mexico area.

The pertinent abstract from minutes of the meeting with the Air Space Sub-Committee of CAA on 17 March 1947 are included in the appendix.

d. Methods of Attack

(1) After a survey of available literature in aerostatics and after conferences with various balloon manufacturers and authorities it is believed that the basic problem of maintaining the 15 lbs. of payload at constant altitude can best be solved by using a non-extensible balloon and a device operated by pressure which drops ballast whenever the balloon descends below a preset altitude.

The specifications for the equipment are as follows:

The balloon should be of large known volume, light in weight, non-extensible, either transparent or highly reflective to solar radiation. Rigging should be used to distribute the load evenly about the balloon.

A safety valve should be used to hold the inflation appendix of the balloon normally closed (as any hydrogen lost decreses the time possible at nominal constant altitude). The valve would act as a safety vent if the balloon should rise appreciably above the altitude where it is fully inflated, as there is danger of rupturing the envelope unless the excess pressure is relieved. The safety valve should be set to release pressure before the limit of the working stress of the balloon fabric is reached.

If the exact volume of the balloon is known and the air density vs. altitude relationship is determined on the day of flight, it is possible to compute the total lift of the gas in the balloon at any altitude. By adjusting the gross load to be supported by the gas to equal the total lift at the desired altitude of flight, the balloon will level off at the desired altitude as it has no further buoyancy. This altitude stability exists only as long as the balloon is in the fully inflated or "taut" state. Once the balloon starts descending (due to loss of hydrogen by diffusion or by other loss) it becomes flabby and is no longer stable. It will continue descending until corrective action is taken or until it reaches the earth.

The altitude control is to be used is the ballast valve. When correctly set it will determine the lower limit of the balloon's oscillation as it would release a free flowing liquid ballast from a reservoir whenever the balloon descends a short distance below a preset altitude.

To test this tentative solution to the basic problem, intermediate sizes of balloon made of suitable fabric or films are needed in addition to the altitude controls.

Balloons

Balloon manufacturers and fabricators of plastic films were contacted to locate a suitable balloon material. The following materials were suggested:

Material	Advantages	Disadvantages	Disposition
Plastic Film			
Polyethylene	Good low temperature properties (Gen.Mills desires to fabricate Picard's balloons from this).	Low tensile strength, Milky-translucent, Medium permeability.	10 ea. 15 ft. balloons being fabricated from it.
Saran	Transparent, low permeability, high tensile strength.	Tears easily, fair low temperature properties (?), weak at seams if heat sealed.	5 large balloons being fabricated.

Nylon	Good low temperature properties, easily fabricated, strong.	Not available, low tear resistance (?)	Awaiting sample.
Vinylite	Easily fabricated. Almost transparent.	Very poor low temperature properties.	Discarded.
Teflon	Strong	Can not be fabricated.	Discarded.
Ethocel	Easily fabricated. Good low temperature characteristics.	Very high permeability.	Discarded.
Pliofilm	Easily fabricated.	Poor ultra violet properties, poor low temperature properties.	Discarded.
<u>Coated Fabrics</u>			
Nylon coated with neoprene butyl rubber polyethylene saran	Strong, easily fabricated.	Heavy, expensive opaque, nylon cloth has relative high elongation.	Awaiting Investigation.
Fortasin (regenerated celulose rayon) coated with neoprene butyl rubber polyethylene saran			Awaiting Investigation.
Silk coated with neoprene butyl rubber			Awaiting Investigation.

As a result of this preliminary study a sub-contract was given to H. A. Smith, Coatings Inc. of Mamaroneck, New York, to fabricate balloons with the following specifications for test purposes:

3 foot diameter balloons, no attachments excepting an inflation tube or appendix made of the balloon film about 10 inches long and 1.4" diameter.

2 each made from Polyethylene PM-1 film .004" thick
2 each made from Polyethylene PM-1 film .008" thick
2 each made from Saran type M film .00225" thick

15 foot diameter balloons with inflation tube 4" in diameter and 12" long, also means for attaching rigging lines supporting a 25-pound load to bottom of balloon and means for attaching auxiliary lifting balloons to top of balloon. If possible, balloon should be capable of withstanding internal pressure equivalent to 2" water.

5 each made from Polyethylene PM-1 film .004" thick
5 each made from Polyethylene PM-1 film .008" thick
5 each made from Saran Type M film .00225" thick

(1) The balloon film should be treated before or after manufacture in such a way as to seal all pinholes.

(2) A patching kit should be furnished for use of the balloon flight personnel.

(3) It is desired that either the volume of the 15 foot balloons be known to within 10 to 20 cubic feet when fully inflated or that the volume, though unknown, be nearly the same for each of the balloons of this size (differences in volume should not exceed $\pm 1\%$ of the total volume of a mean balloon).

Delivery was made 20 April 1947 on the first 3 foot balloons, two 15 foot balloons are expected by the end of May.

In an attempt to interest another manufacturer in the problem, the following companies were contacted.

Company	Type of Company	Interested?	Disposition
Dobeckman Co. 500 Fifth Avenue, NYC	Plastics & Packaging	No	None
Kennedy Car Liner & Bag Co., Shelbyville, Ind.	Plastics & Packaging	No	None

Plextron Inc. 55 Tremont Ave., Bx 57	Beach Balls	No	None
DuPage Plastics Co. 475 Fifth Ave., NYC	Beach Balls	No	None
Shellmar Products Inc. Empire State Bldg., NYC	Plastics & Packaging	No	None
Millprint Inc. Milwaukee 1, Wisconsin	Plastics & Packaging	No	None
Celanese Plastics Corp. 180 Madison Ave., NYC	Plastics & Packaging	No	None
E. L. Cournand Co. 2835 9th Ave., NYC	Plastics & Packaging	No	None
Bland Charnas Co. 24 Ashburton Ave,Yonkers	Toys, Beach Balls	No	None
Western Products Inc. Newark, Ohio	Plastics & Packaging	No	None
Rowe Packaging Co. 26 Queens St. E. Toronto 1, Ontario Canada	Plastics & Packaging	No	None
Goodyear Tire & Rubber Co., Akron 16, Ohio	Blimps & Balloons	Yes	Awaiting final decision.
Molded Latex Products Inc., 27 Kentucky Ave. Paterson 3, N. J.	Balloons (Meteorological)	Not very.	None
Air Cruisers Inc. Clifton, N. J.	Balloons (Meteorological)	Yes	Awaiting final decision.
General Mills Inc. 1837 Pierce St. N.E. Minneapolis 13, Minn.	Balloons (Picard's)	Yes	Awaiting visit.
Seyfang Laboratories 1300 Mediterranean Ave. Atlantic City, N. J.	Barrage Captive & Other Balloons	Yes	Awaiting final decision.
Dewey & Almy Company Cambridge 40, Mass.	Meteorological Balloons	No	None

On completion of the survey of balloon materials other orders will be placed for experimental intermediate balloons.

As soon as a series of successful flights are obtained, it is planned to procure balloons of about 8 times the displacement of the intermediate size for tests as the model to solve the problem. These larger balloons would be about 30 feet in diameter.

Altitude Control

Mr. Goudy of the Kollsman Instrument Division of Square D Corporation was contacted to determine the feasibility of:

(1) An accurate pressure-actuated liquid ballast dropping device.

(2) A motor-switched modulator for the standard Army radiosonde AN/SMT-1. The standard pressure-switched modulator would be of little value in determining the height of the constant level balloon after it leveled off on a constant pressure surface.

On a subcontract Kollsman undertook to build a pressure actuated "dribbler" or ballast dropping device as follows:

Mechanically Controlled Dribbler

To consist of a diaphragm operated needle valve which will allow no flow for a 2 mb. increase in pressure on the diaphragm over pressure of which diaphragm is sealed but will allow a flow of 40 grams/minute under 1 foot of lead for a 5 mb. increase in pressure. Petroleum ballast with a density of about .775 gm/cc is to be used.

Diaphragm to be open to the atmosphere until it is sealed off by the radiosonde pressure switch at a preset altitude.

An electrically operated needle valve was included in the order, however it is to be cancelled as the mechanical valve appears more feasible to the manufacturer.

As the motor switched modulator was already in experimental state of manufacture for the Signal Corps and Evans Signal Laboratories an order was placed for 3 of them with these characteristics:

To have a motor-driven commutator to contain 4 contacts alternately switching two different temperatures, pressure and a reference. Rate of switching will complete one cycle per minute. To report pressure accurately between 150 and 500 mb. with a pressure resistor to be of such a valve that with a large radiosonde frequency variation for a small change in pressure.

To have an adjustable contact variable between 250 mb and 400 mb with a factory adjustment of 300 mb. When the pressure arm reached this contact, a squib will cut a thread that holds the ballast diaphragm open.

The first mechanical dribbler was received on 20 April 1947 and is undergoing modification and tests before being flown on Cluster Flight #2. If it is successful, an order for improved models will be placed.

Another method maintaining a balloon at constant altitude is by replenishing the hydrogen in the non-extensible envelope as it is valved or as it diffuses. This might be accomplished by use of liquid hydrogen but not by use of chemicals due to their great weight relative to the small volume of hydrogen generated. The liquid hydrogen method is being investigated with a long range view. It does not seem too feasible, however, due to the difficulties of keeping the rate of evaporation of the liquid hydrogen low at the high altitudes, without extensive and heavy guard flasks of liquid air.

A third method of holding the equipment at a nominal constant altitude is to fly a cluster of standard meteorological balloons equipped with ballast dropping devices and a device for releasing lifting balloons should the cluster depart from the altitude limits desired. This method is inherently unstable, as there are no proportional restoring forces which will act on the flabby, freely extensible meteorological balloons. The success of this procedure depends on very careful balancing of the load against the variable lift of the balloons.

This cluster method is of use and interest only as a stop-gap method of lifting the Army equipment to altitude now, and has been the method used while awaiting delivery of the non-extensible plastic balloons.

III d) e. A flight was made on 3 April 1947 using this method. A cluster of 12 balloons meteorological carrying a radiosonde, a 15 lb. dummy load and a series of ballast dropping devices was released from the football field at Lehigh University, Bethlehem, Pa. The train was to be towed to 30,000 ft. by 2 lifting balloons which would then be cut loose. The weight of the equipment was adjusted to equal the lift of the balloons and presumably the train should have floated after the towing balloons were cut off. Actually, due to lack of experience in the difficulty of handling long balloon trains, auxiliary rigging lines were needed to take up launching stresses. These lines fouled the main flying line and the ballast which was to be dropped on parachutes. As a result, the balloon train went to 50,000 ft. where the tow balloons worked themselves free. The remaining train thereupon descended as fast as it had climbed (1,000 ft. per minute), landing in the ocean near Sandy Hook,

N. J. The flight was of value in training personnel, establishing a net for reception of the 74 megacyle radiosonde data, and in obtaining familiarity with the type of operation peculiar to all large balloon flights. The actual layout of the train used is sketched in the appendix.

Using the lessons learned on the dummy flight, improved equipment was built for a flight with a payload. Release was attempted on 18 April. Due to the high wind at 0830 EST, the time of release, and due to malfunctioning of the Army receiver in the plane that was to follow the balloons, release was not made. The already-inflated balloons were cut free and the equipment was brought back to New York University. It is expected that this equipment will be flown about 8 May. A description of the final flight equipment will be given in the report for May. A sketch of the layout of equipment built for the second cluster flight is given in the appendix. As this is a stop-gap method using modified standard components, no detailed report is being prepared on the equipment. Preliminary altitude controls used in both flights consist of standard radiosonde modulators ML-310 which have had leads taken off of the desired contacts of the commutator. The modulator thus acts as a pressure actuated control that releases ballast or balloons. In the first flight small radiosonde relays were used to close circuits to burn off cans filled with ballast. In the improved, second flight, a nest of plastic tubes were filled with dried sand. The bottom of the tube was covered with paper and a DuPont type S64 Squib was placed on the paper under the sand. On firing the squib, a hole is torn in the paper, permitting the sand to trickle out. This method permits dropping of more ballast and yet, in smaller increments. In the second cluster flight, provision was also made to release balloons if the train rose above 40,000 ft. The flying line in the second train was approximately 500 ft. long.

This cluster flight is tedious to prepare and difficult to launch, and is a greater hazard to aircraft than the plastic balloons will be because of the great length of the cluster train.

III e) Apparatus and Equipment.

A detailed explanation is not given on the equipment of the Cluster Flight. However, a layout sketch is enclosed in the appendix. An important piece of new apparatus for this project is the ballast valve or dribbler, a photograph and drawings of which appears in the appendix. It consists of a special diaphragm which operates a needle valve. Normally the valve is closed as the diaphragm is open to the air before the balloon reaches the desired altitude. This allows the pressure inside the diaphragm to be the same as the outside pressure. The diaphragm is sealed electrically by the baroswitch of the flight radiosonde when the balloon train passes a predetermined altitude. Whenever the balloon train descends below this preset altitude, the increase of pressure on the sealed diaphragm causes the needle valve to be opened. The greater the excess in pressure on the diaphragm the more ballast there is released through the valve. Thus a proportional restoring force is applied to the train. The ballast that is to be used is a petroleum cut boiling from 300° to 400°F with a density of about .78 and a minimum change of viscosity with temperature. Two different type fluids that may meet this specification are the Army type compass fluid and a Sinclair paint solvent. The ballast valve or dribbler essentially perform the same function as the Japanese altitude control on the balloon bombs yet it is simpler and permits use of a liquid ballast for better control.

Another piece of equipment that is under construction by Kollsman Instrument Company is a motor-switched radiosonde modulator. It presents pressure data to the radiosonde transmitter as a variable resistance. The meteorological data is programmed by a samll Brailsford Electric motor. This modulator will provide the contact that seals off the diaphragm in the ballast valve. A complete discussion of this equipment will be furnished upon its delivery.

Sketches of balloon and rigging of the balloon to be used on to the main problem are given in the appendix and are self-explanatory.

Computations

A chart showing the relation between altitude, gross lift, and balloon size has been found necessary.

Data for it was computed using mean aerological soundings as reported in the Monthly Weather review for 1943.

A chemical term, molar volume (in cubic feet) was used as a term relating the sounding data with buoyancies of the balloons at various altitudes.

Using the simple gas laws, the molar volume of dry air was computed thus:

I. (1) Molar volume of any gas at standard conditions is 359 $ft.^3$

(2) From Monthly Weather Review Jan. 1943, the mean sounding data at 15 km for Lakehurst, N. J. is: Temperature $-59.5^{\circ}C$

Pressure 120 mb.

$$359 \times \frac{273.2 - 59.5}{273.2} \times \frac{1013.3}{120} = 2370 \text{ ft.}^3$$ (the mean molar volume at 15 km for Jan.1943 over Lakehurst,N.J.)

This volume data was computed for all lovels given. Data was "borrowed" from other stations in the same latitude to piece out the 20 km soundings as needed.

II. Lifts were computed for various molor volumes for balloons between 7.5 and 75 feet diameter in the following manner:

Given

purity of Hydrogen 99.7%
impurity as oxygen 0.3%
computed molecular wt. 2.11 #1 mol
Molecular weight of dry air as computed from data reported at 10 km. in Handbook of Chemistry and Physics.
28.764 #1 mol

To find the lift of a 20'^{D} balloon at an altitude where the molar volume is 1000 ft.^{3}:
Volume 20 ft.^{D} Balloon = 4190 ft.^{3}

$$\text{Lift/Balloon} = \frac{\text{Balloon Volume X(Difference in molecular wgts.of air\#hgn}}{\text{Molar Volume at a given altitude}}$$

or

$$\text{Total Lift of gas in \#/Balloon} = \frac{\text{ft.}^3\text{/Balloon X (\quad \#/mol)}}{\text{ft.}^3\text{/mol}}$$

for the 20 foot diameter balloon:

$$\text{Lift} = \frac{4190\ (28.76 - 2.11)}{1000} = 111.7\#$$ lift from a 20 foot diameter sphere of hydrogen at an altitude where the molar volume is 1000 ft.^{3}.

The lifts were plotted against molar volume for each size balloon. The altitudes corresponding to various molar volumes for Lakehurst and Albuquerque in January and in August 1943 as computed above were plotted on the left margin of the chart.

The family of curves was plotted on log paper and is included in the appendix with the basic sounding data.

III g) Conclusions and Recommendations.

It is believed that a balloon can be kept at nominal constant altitude between 10 and 20 km. for six hours using a non-extensible envelope with the addition of a ballast valve to keep the balloon near its pressure altitude. The flying of a balloon thus equipped is our main objective. The work to date has been primarily preparatory but it is believed that plastic balloons can be flown in the early summer with a payload.

Additional work space is urgently needed at New York University if significant work is to come from this group.

It is believed that the ideal launching area for balloons of this type is Lehigh University, Bethlehem, Pa. as long as this is feasible, For large balloons it is believed that the Navy people at Lakehurst can best facilitate the launching. Calm winds are essential for actual launching.

Future Work

General Mills is making large balloons from lightweight films that would meet our specifications with the exception that they cannot take any internal pressure. It is believed that their balloons should be investigated as General Mills appear to be the best source of supply for large balloons. An order will be placed with them as soon as they furnish a quotation.

As a stop-gap device before these might arrive it is planned to fly two 35,000 cu.ft. racing type as well as the 2 Japanese balloons from Lakehurst, N. J. carrying payloads with heavy duty power supplies for the radio transmitters.

In the meantime, improved clusters of meteorological balloons will be flown until larger balloons are available.

C O P Y

Abstract from:

AIR COORDINATING COMMITTEE
NEW YORK SUBCOMMITTEE ON AIRSPACE
RULES OF THE AIR AND AIR TRAFFIC CONTROL
385 Madison Avenue
New York, 17, N. Y.

N.Y. Meeting No. 12 20 March 1947

PROBLEM:

1. The Secretary of the Subcommittee presented a request from the War Department member in behalf of New York University for approval to release free balloons from Allentown, Pa. and Lakehurst, N. J.

DISCUSSION

2. The subject project is broken down into two phases as described below:

A. PHASE I.

(1) The type balloon to be used in this phase of the project will be 6 ft. in diameter, hydrogen filled, encompassed by a nylong shroud with black and white panels 24" wide. Radio instruments weighing approximately 3 lbs. will be suspended approximately 50 ft. below the balloon and equipped with parachute device so that upon separation from the balloon, the attached equipment will float down towards the earth rather than become a freely falling body.

(2) It is anticipated that two flights will be required in this phase of operation, the release to be made during weather conditions in which the sky is free of clouds and the visibility at least three miles at all altitudes up to 20,000 feet., within a four hour cruising radius from Allentown, Pa.

(3) The balloon, during these flights, shall be convoyed by suitable aircraft to maintain air-ground communications on the balloon trajectory and equipped to effect destruction of the balloon at the termination of four hours flight or at such time that the balloon may become hazardous either to aircraft flight operations or the persons or property of others on the surface.

(4) New York University will file a Notice to Airmen at least twelve (12) hours in advance of balloon release and a second notice will be filed at the time of release with the Allentown, Pa. Airways Communications Station.

B. PHASE II.

(1) The type balloon to be used in this phase of the project will be a 15 to 40 ft. diameter plastic balloon, hydrogen filled. Radio equipment weighing approximately 25 lbs., will be suspended approximately 100 ft. below the balloon. The balloon will be towed to high altitude levels (above 20,000 feet) by three auxilliary lifting balloons fastened together with a 4 lb. weight. All equipment attached to the balloon will be equipped with parachute device so that upon separation from the balloon, the attached equipment will float down towards the earth rather than become a freely falling body. Upon attaining the desired altitude, the auxilliary lifting balloons wife be released from the main balloon.

(2) It is anticipated that a maximum of ten flights will be required in this phase of operation, 2 to 5 releases to be made from Allentown, Pa. and 2 to 5 releases to be made from Lakehurst, N. J. Release will be made during weather conditions in which the sky is free of clouds and the visibility at least three miles at all altitudes up to 20,000 feet.

(3) The range of flight during this phase of operation will bebetween 30,000 and 60,000 feet. A period of six hours will be the maximum duration of flight.

(4) New York University will provide an operator for tracking of the balloon during period of flight and will furnished information on its position to the N. Y. Air Traffic Control Center during period of flight.

(5) New York University will file a Notice to Airmen at least twelve (12) hours in advance of balloon release and a second notice will be filed at time of release with either the Allentown, Pa. or Lakehurst, N. J. Communications Stations.

(6) Destruction of the balloon will be predetermined to be effected over water where hazards are not present. Aerial convoy will not be effected during this phase of operation inasmuch as balloon flights will be conducted in excess of 20,000 feet.

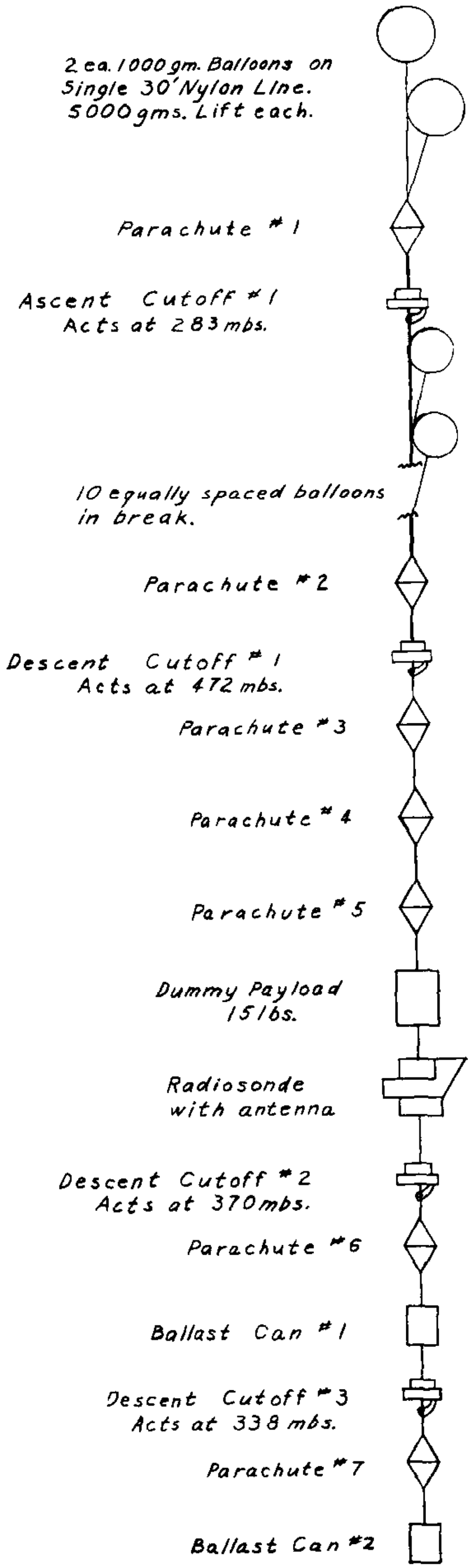
3. The War Department member requests that balloon operations along the lines of Phase II be presented to the Washington Subcommittee for clearance with all other Regional Airspace Subcommittees, in consideration of War Department plans to continue the Phase II type of operation from White Sands, New Mexico, upon completion of the 12 proposed releases described herein. The type of balloon releases proposed out of White Sands, N. Mex., will involve flight through other regions.

RECOMMENDED ACTION

4. That the release of free balloons by New York University as described above in Paragraph 2-A (Phase I), Subparagraphs (1) - (4) inclusive, be approved.

5. That the release of free balloons by New York University as described above in Paragraph 2-B (Phase II), Subparagraphs (1) - (6) inclusive, be approved.

6. That the Washington Airspace Subcommittee present the Phase II operation to other Regional Airspace Subcommittees for clearance, in view of War Department plans to continue the Phase II type of operation from White Sands, New Mexico.



All individual balloons on single 15' Nylon lines and tied onto Main Line at 20' intervals.

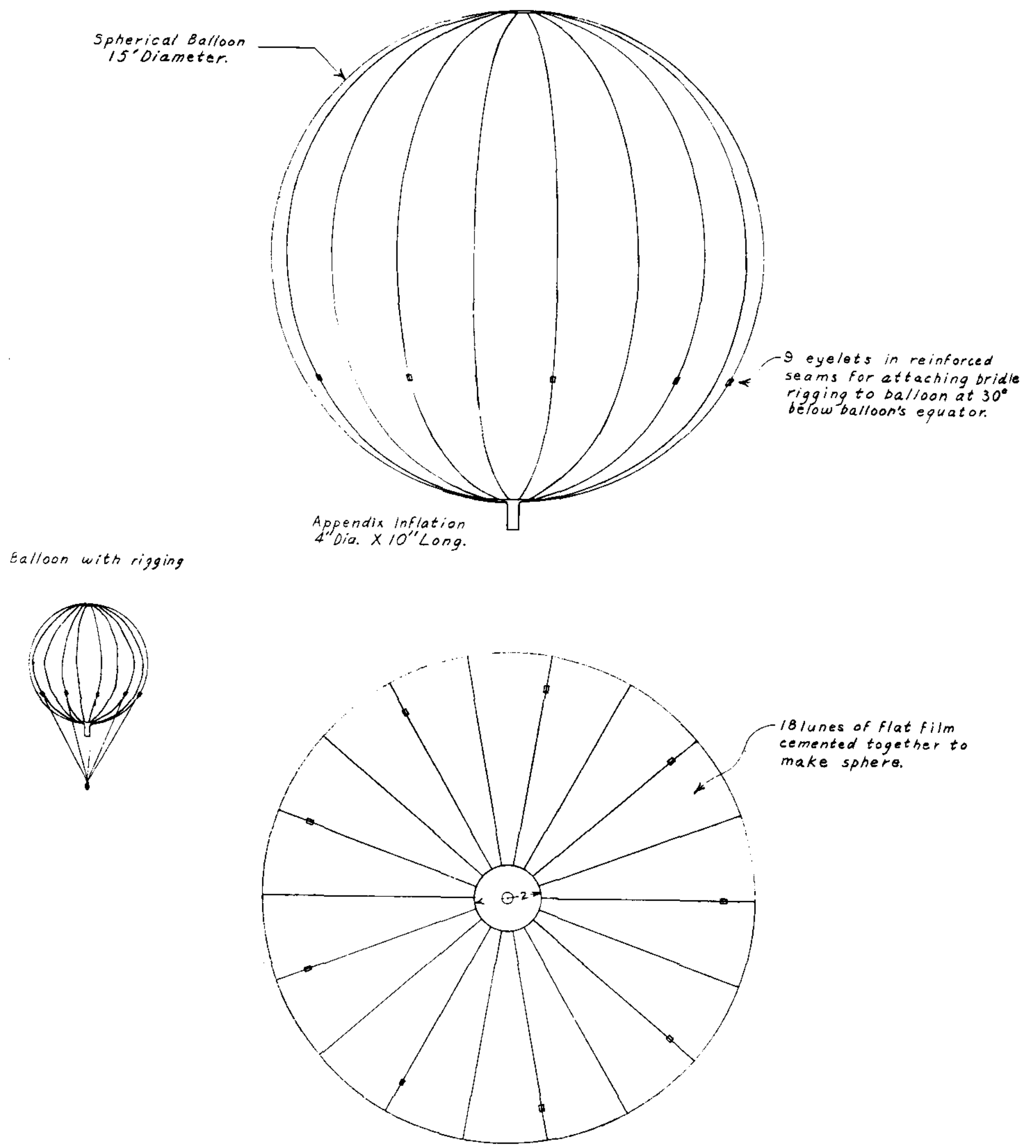
Flying line from Cutoff #1 to Parachute #2 is braided for added strength.

There is a distance of 5' between each piece of equipment, except the 20' between balloons on the Main Flying Line.

The 12 balloons on the braided line are each 350 gm. balloons with a lift of 1550 gms. each.

BALLOON TRAIN FOR CLUSTER FLIGHT NO. 1

BETHLEHEM, PENNA.
3 APRIL 47.

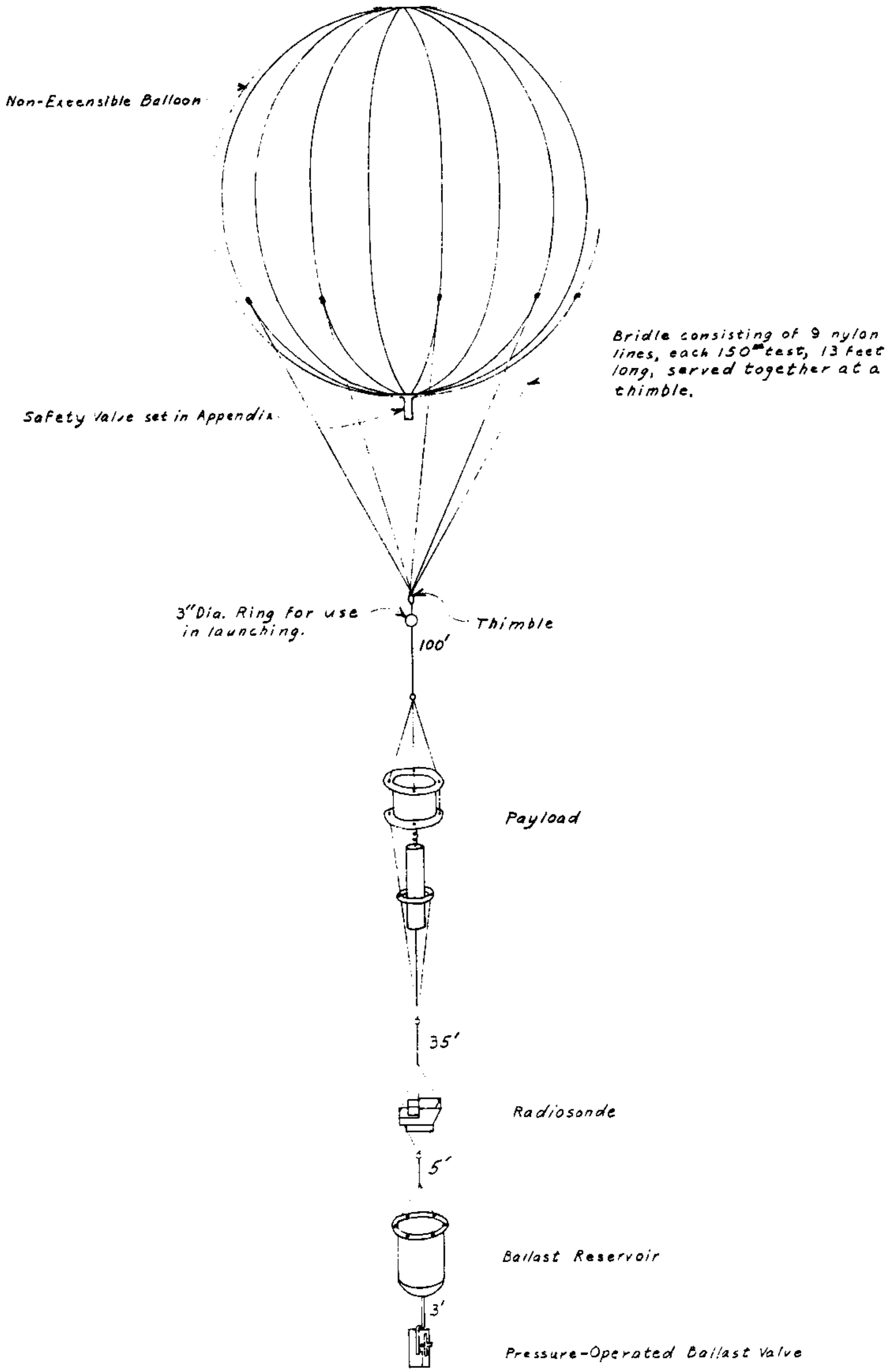


PLASTIC BALLOON

FOR CONSTANT LEVEL BALLOON PROJECT AT NYU

APRIL 27, 1947

SCALE: 1" = 3' 0"



PROPOSED ASSEMBLY OF
TRAIN FOR CONSTANT LEVEL BALLOON

APRIL 27, 1947 SMITH, JAMES F.

LAKEHURST (39 meters)

	JANUARY 43				AUGUST 43 -				
Alt.Ft.	Temp.°C	Press mb	Humidity%	Molar Vol. ft.^{3}	Temp.°C	Press mb	Humidity%	Molar Vol.ft^3	Alt.Ft.
65,617	-58	53	--	5410	- 64	58	--	4850	65,617
62,336	--	--	--	--	--	--	--	--	62,336
59,055	--	--	--	--	212.0 - 61.2	79	--	3585	59,055
55,774	--	--	--	--	337.2 - 64.2	94	--	2962	55,774
52,493	--	--	--	--	338.6 - 65.6	110	--	2370	52,493
49,212	213.7 -59.5	120	--	2370	337.1 - 64.1	130	--	2150	49,212
45,931	215.8 -57.4	140	--	2050	333.7 - 60.7	153	--	1845	45,931
42,651	216.3 -56.9	164	--	1808	329.4 - 56.9	179	--	1630	42,651
39,370	217.2 -56.0	192	--	1506	304.0 - 51.2	209	--	1440	39,370
36,089	-54.1	224	--	1339	318.0 - 45.3	243	--	1250	36,089
32,808	-51.0	262	--	1130	311.2 - 33.2	282	--	1115	32,808
28,527	-45.5	304	--	995	303.4 - 30.4	325	--	1000	28,527
26,247	-38.8	352	--	888	296.0 - 23.8	374	--	890	26,247
22,966	1 -32.1	408	--	788	290.0 - 17.0	428	--	800	22,966
19,685	248.2 -25.0	469	--	705	283.1 - 1[illegible].1	488	31	718	19,685
16,409	254.3 -18.9	536	60	632	276.9 - 3.9	555	28	650	16,409
13,123	-13.0	611	59	566	1.5	629	38	582	13,123
9,843	- 8.5	696	60	507	6.4	711	49	5[illegible]3	9,853
8,202	- 6.4	742	61	478	9.0	756	51	499	8,202
6,561	- 4.5	791	65	453	11.9	802	55	474	6,561
4,921	- 3.2	843	69	427	15.0	852	63	452	4,921
3,281	- 2.5	898	68	401	18.6	903	58	432	3,281
1,640	- 1.7	956	69	378	21.7	956	60	413	1,640
0	- 1.0	1013	76	359	21.5	1008	76	385.9	0

ALBUQUERQUE (1620 meters)

	- JANUARY 43				- AUGUST 43 -				
Alt.Ft.	Temp.°C	Press mb	Humidity%	Molar Vol.ft.^{3}	Temp.°C	Press mb	Humidity%	Molar Vol.ft.^{3}	Alt.Ft
65,617	-63	54	--	5410	-58.1	58	--	4960	65,617
62,336	--	--	--	--	--	--	--	--	62,336
59,055	-65.1	75	--	3701	--	--	--	--	59,055
55,774	-64.3	88	--	3170	-70.0	96	--	2830	55,774
52,493	-63.0	104	--	2700	-69.8	114	--	2430	52,493
49,212	-61.6	122	--	2320	-66.4	134	--	2060	49,212
45,932	-60.2	143	--	1990	-61.5	138	--	1780	45,932
47,651	-54.1	168	--	1690	-54.7	186	--	1560	47,641
39,370	-57.2	197	--	1450	-47.0	217	--	1390	39,370
36,089	-54.7	230	--	1250	-39.4	251	--	1250	36,089
32,808	-49.7	269	--	1140	-31.6	290	--	1110	32,808
29,527	-43.0	312	--	983	-24.2	333	45	980	29,527
26,247	-35.7	362	39	872	-17.1	382	45	895	26,247
22,966	-28.3	416	45	786	-11.0	436	56	803	22,966
19,685	-21.2	477	48	704	- 5.6	495	72	715	19,685
16,404	-14.6	546	50	631	1.1	562	79	652	16,404
13,123	- 8.3	622	51	567	3.8	634	66	594	13,123
9,843	- 2.6	706	48	522	16.6	715	48	541	9,843
8,202	.6	752	45	486	20,4	758	42	517	8,202
6,562	3.4	800	46	463	23.3	803	39	492	6,562
0	3.8	838	45	449	25.2	838	44	430	0

Sfc 1620 meters = 5315 feet

Fiscal Report As of April 30th, 1947

Total amount expended	$20,067.96
Available Balance	97,632.04
Total	$117,700.00

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Journal Transcriptions
Albert P. Crary
April 2, 1946–May 8, 1946, *and*
December 2, 1946–August 16, 1947

April 2 Tues D & I left caracas Pan Am bus 9 pm. Arrived Miami 10 pm on Pan Am. through customs and caught 1 am National Airlines plane for Newark

April 3 Wed Arrived Newark 730 am and took airline bus to NYC. D left for Providence 9 am. Called up Ewing but he was in Chicago - due back tomorrow. Left on 1040 sleeper for Canton tonight.

April 6 Sat At home. Over to Ogdensburg to see Steve this pm

April 7 Sun. Left Canton on 805 sleeper. Saw Bob Foster '31, also on way to NYC

April 8 Mon. Arrived NYC 730 am. Up to Columbia University to see Ewing 130 pm. Wyckoff and Dove on way to Los Angeles by plane this pm. Crane and Morrison in also from Watson Labs. Went back to Red Bank with them in AWS car to Officer's Club near Watson Lab. Crane, Morrison and I went up tonight to see Reinnegle at office. Met Gifford who has 80' sea rescue boat this project is planning to use. Stayed at Officer's Club tonight

April 9 Tues. At Watson Labs all day. Went through all processes necessary for employment under Civil Service. Warrant Officer Gifford transferred to WLERL-4 today. McCurdy already in and started work. Talked with Reinnagle and Gallo re Columbia contract. Gifford left pm for Washington, Major Crane for Camp Dix and Morrison for NYC. Reinnagle and I went down to CO this pm to meet group from Cornell extension at Buffalo - Aeronautical research wanting to get contracts. Stayed at Molly Pitcher Hotel in Red Bank tonight

April 10 Wed Checked out of Molly Pitcher Hotel and caught 730 am train out of Red Bank to NYC. Checked in at Hotel Webster and then up to Ewings at Columbia University. Mr Gallo of Watson Labs in at 10 am and we went over contract questions regarding Watson Lab contract with Columbia until 1 PM. Went over all parts of work with Doc from 2 to 530 pm. John Ewing in from Missouri.

April 11 Thurs. Worked on rough outline of Eglin Field and SOFAR project Am. Up to see Ewing at Columbia PM. Doc and I went over contract with Watson Lab & Columbia tonight. Caught 1205 sleeper to Boston.

April 12 Fri. Arrived Woods Hole about 11. Joe Worzel went over all sound transmission work at WHOI this pm.

April 13 Sat. Talked with Columbus Iselin this Am regarding Watson Lab work and needs. Crane and Gifford up pm and Joe and I went up to lab with them.

April 14 Sun. Down to lab this am with Joe looking for G9A files. Jim Peoples over about noon for awhile. Joe and I went golfing pm. Took 600 pm train to Boston and 1230 sleeper to NYC. Up to Boston with Lt Frank Ryder with Navy and WHOI

April 15 Mon. Contacted Doc Ewing in NYC and rode down to Red Bank with him. Talked over instrumentation of upper atmosphere investigations. Out to Oakhurst this pm. Conference with Col. Cole and Col. Grough re Project 188-5 and regarding microseisms. Doc and I went back to Molly Pitcher Hotel in Red Bank tonight.

April 16 Tues. Rode out to Watson Labs with Ewing. Went over to Evans Labs with Harry Davis Watson Lab navigation man, and saw newly developed ranging apparatus and talked to Lt Rydetor? re Spherics, location of lightning and thunderstorm data collected during past few years. Saw Col. Duffy of Meteorological Division AAF and back to Watson Labs. Doc went on through to NYC. Went over program with Dove and Crane this pm. Back to lab tonight with Crane and Gifford, discussing Project 185-7-1. Back to Myrtle Hotel at 1045 pm.

April 17 Wed. Rode out to Watson Labs with McCurdy. Worked with Major Crane on report regarding underwater work, Eglin Field and deep water. Took this in to Colonal Cole this pm. Acceptance probable. Got room in private house in Red Bank. Moved out of Molly Pitcher Hotel.

April 18 Thurs. Caught bus out to Watson Lab. Col Cole up this am and advised writing new Cost Expenditure for and revising the R. & R. Major Crane left about noon for trip Phila and Woods Hole. Made arrangements to meet him in NYC Monday. Wrote out new R & R and Cost Expenditure ready to take to Col Cole.

April 19, Fri. Talked over work with Dove and we wrote up 2nd EO covering all ocean work. Talked to Ewing on phone this am. Dove and I went down to see Col Cole and then wrote up new EO for deep water work. Saw Hincke? regarding this EO and A for P processed this pm and ready to go out to Wright Field.

April 20 Sat. Caught 710 train to NYC, cashed check at Chase Natl Bank, talked to Ewing on phone. Back to Red Bank about 4 pm.

April 22 Mon. At Watson Labs this am. Got final physical exams. Down to Supply to see Major Morris with Reinnagle re getting equipment out that came from WHOI without paper coverage. Got travel order back and authority to use it. Caught 342 pm out of Red Bank and arrived in Newark about 430. Reservations to Dayton on Spirit of St. Louis had been cancelled. Called Watson Labs. Got roomette on Spirit about 530. Called Mrs Ewing in NYC. Left Newark on Spirit of St Louis at 620 pm.

April 23 Tues. Arrived Dayton, Ohio about 830 am. Tried to get return ticket for tonight but coach car only open. Took bus out to Wright Field, Bldg 28. Saw Mr Drexler and turned over 2 of the A for P to him. Colonel Maier on leave. Went down to Colonel Winter's office and found Major Crane there. We talked to Colonel Winters regarding the need for planes and about new EO on extended long ranges of the 189-7-1 program which he approved and marked up to 1-P & sent on for higher approval. Went over with Crane & saw Colonel Lind gard in the plane assignment division and talked about planes. Had lunch with him and then went back to talk to Colonel Eaton regarding planes to 189-9-1. Went over to look at C-97, converted B-29 for transport. Back to Bldg 28 & talked with General Rives. Request for planes agrred upon and B-29 will be available near the 1st of June. 189-7-1 required by Rives. A for Ps in Drexler's office not yet signed. - will be sent on to Watson Labs later. Crane had reservations for me on the Spirit of St Louis and we left Dayton at 8 pm.

April 24 Wed. Discussed with Crane possibilities of getting sound through the ground part of the ocean sound channel and about the possibilities of a balloon such as Piccards. Arrived in NYC about 1030. Called Watson Labs and then we took a taxi up to Ewing's office at Columbia. After Ewing 1-2 class we discussed plans for 188-5 and 189-7-1, both Eglin Field and long range channel program. Left Ewings office about 6. Crane registered at Hotel Lexington and I caught 740 out of Penn Station and arrived at Red Bank at 845 pm

April 25 Thurs. Up to Watson Labs. Worked over notes of conference with Ewing yesterday. Wrote up both travel blanks and sent them down to Travel Order Section. Talked with Palmer about MQ travel forms. Wrote up letter to Wright Field requesting use of second crash boat. Wrote R&R for Mark 2 hydrophone. Talked to Lt. Hungerford regarding request of this. Stepanoff, new physicist for WLERL in this pm. Crane left for Wright Field tonight.

April 26 Fri. Up to Watson Labs. Went over purchases already applied for with Reinnagle. Wyckoff in this am. McCurdy in pm for radio parts. Went back to Oakhurst with McCurdy this PM

April 27 Sat. Left Red Bank about 730 AM with McCurdy in his car. Drove through NJ at TRenton & down to Philadelphia. Mac left me off at Olney at subway station. Contacted Marion at Bankers Security and went by train with her to Newton, Pa at 100 PM . Stayed with Flaggs.

Apr 28 Sun. Wayne & Marion drove me over to Trenton, NJ & I caught 1030 am train into NYC. Went up to Ewings about 1215. Joe Worzel there & Hilly Barbour. They left for Woods Hole about 2 PM. I caught 550 train out of Penn Station to Red Bank, NJ

April 29 Mon. Up to Watson Labs. Checked over at library to have some periodicals obtained. Went over water work with McCurdy regarding what is needed in way of purchases. Went over to Oahhurst with Roke, new engineer, former Lt. Commander in Navy. Talked to Charlie Ireland regarding Eglin Field work.

April 30, Tues. Up to Oakhurst. Went over equipment that would be left there and what we might do when rest of people gone to Whitesands with Wyckoff. Wyckoff and I took car to Watsom Labs to conference with Col Duffy of Weather Bureau, Capt Kellogg and Col Gault. Discussed weather problems - on eqpt? and S658s & aerography neede in coming work. Discussed equipment with McCurdy pm and tried to find where demolition cable could be located.

May 1 Wed. Up to Watson Labs. Talked with Stepanoff and Wyckoff regarding work to be done while crew was recording White Sands in New Mexico. Commander Navy arrived about 1130 am and we held a conference - Gault, Compton?, Dove Crane, Wyckoff, Hungerfield, Vaux and myself regarding Navy participation with us in Crossroads. Captain Kellogg of Weather Service over pm and talked with Crane and I regarding 658s, airgraphs, etc. Got travel orders etc to Columbia tomorrow. Wyckoff and about 11 others leaving for White Sands by plane tomorrow morning. Up to lab tonight with Crane.

May 2 Thursday. Left Red Bank on 8 am train, off at Elizabeth and took ferry to NYC. Up to GCT and then up to Docs. Too late for talk with Kellogg but in time for conference with Ewing, Lane of Columbia, Gallo, Bradford, Dove and Crane of Watson Labs. Conference went over contracts with Columbia and WL. Crane and I talked to Dove for short time after dinner. Caught 1130 sleeper to Boston tonight.

May 3 Fri. Arrived Woods Hole 1045 am . Went over to Falmouth with Dorothy. Up to lab pm with Joe W. Talked to Jim Peoples re his amplifier and level recorder. Bump and Kit over tonight. Saw Columbus PM.

May 4 Sat. Up at WHOI this am. Out with John Ewing taking bottom shots in water. Worked with Joe on his boat this pm. Over to Jim and Rowes tonight and to Buzzards Bay bowling.
May 5 Sun. Up to WHOI about 11. Went over deep water equipment with Joe Worzel and Jim Peoples. Jim and I caught 600 pm train to Boston tonight, got 1130 pm Owl to NYC
May 6 Mon. Caught 625 train out of Penn Station to Red Bank. Arrived Red Bank 730 and caught bus out to Watson Labs. Checked at library for caps?military info. Called up Morris of Supply and wrote supply request. Stepanoff in fm Oakhurst. Wrote up weekly report to Watson Labs for 189-7-1. Arranged truck to take fathometer to Nyack, N.Y. for 104' boat and bring back microbarograph from Columbia. Went out to Oakhurst and saw Rooke who is working on fluxmeter, and got fathometer NMB-1 ready to send to Nyack. Went over list of parts needed 189-7-1 with Peoples. Peoples signed in at Watson Labs today. Capt Kellogg in from Evans Labs re how they can help- rough draft of letter of request to be written by Col Graul. Got travel orders to NYC tomorrow and to Nyack.
May 7 Tues. Jim Peoples and I caught 608 train out of Red Bank and arrived Ewing's office about 850 am. Conference at Ewing's office Gallo, Bradley, Crane, Peoples and I from Watson Labs, Lane and Ewing of Columbia and Iselin and McCrory? of WHOI regarding 189-7-1 contract of WHOI with Columbia. Conference later Iselin, Crane, Ewing, Peoples and myself regarding technical procedure and plan for Atlantis, Anton Dohrn and two boats of Watson Lab for summer and next winter. Crane, Peoples and I left about 240 pm for Nyack, NY in Army car. Arrived in Nyack at Peterson's Shipbuilding Co, new 104' boat P778 docked about the same time. Went over all changes and additions to the boat with Gifford and made plans for conversion to our needs. Left Nyack about 6. Jim Peoples and I caught 740 train out of Penn Station and arrived in Red Bank 9 pm.
May 8 Wed. Jim Peoples and I went up to Watson Labs this am

Dec 2 Mon. Oakhurst. Cold wave hit about midnight - temperature down to 15° - strong wind. Started preparations for Alamogordo trip; getting Rubicon drums and galvanometers ready.

Dec 3 Tues. Oakhurst. Worked on Rubicon drums and galvanometers for Alamogordo trip - Stepanoff on August 9 data - Vivian working up cruise tabulations. Oliva setting up new GR3 for Alamogordo. Got oscillograph operating with 3 T-21 microphones.

Dec 4 Wed. Oakhurst. Set up 20 sec galvos and operated for several hours. In with McCurdy to safety meeting, Wl. Chantz set up Rubicon in dark box and took several records with 1 sec galv. Made up list for Alamogordo.

Dec 5 Thurs Oakhurst. Worked on relays for setup at Alamogordo. McCurdy & his group on T-21 operations. Woodruff and Chantz getting motors,etc ready for trip. Went over work at Oakhurst with Vivian.

Dec 6 Fri. Oakhurst. Worked on equipment for Alamogordo. Left at noon, caught 135 to New York City. Contacted Carl Gerdes and Ed Schempf at United Geophysical office. Curtin also in NY office. Went out to eat with Carl and Ed and discussed future work. They have job open for me in Alaska and also later possibilities in Turkey. Ed caught plane out about 745. Left on 1215 tonight for Asbury Park.

Dec 7 Sat. Went to Oakhurst 10 - 3. Woody and Phil there getting ready for Alamogordo. Peoples up for awhile pm.

Dec 8 Sun. Worked about 7 - 8 hours at Oakhurst. Chantz and Peoples there - getting realys, etc ready for Alamogordo. Went over all theoretical work on flights, etc with Peoples.

Dec 9 Mon. Oakhurst. Finished getting all equipment ready for Alamogordo. Chantz, Woody and I went to Watson Labs. Got checks and travel orders. All equipment loaded on trucks and taken to Watson late pm. Talked to Colonel Duffy a while about future plans.

Dec10 Tues. Woody, Chantz and I left Oakhurst in staff car about 9 am. Arrived at Newark airport 10. C-54 in from Middletown about 11, bringing Ball and Oakes from Wright Field. Loaded up all equipment on C-54 and left Newark about 145 pm. Lewis, pilot; Clowry, co-pilot. Arrived Oklahoma City about 945 pm EST. Got rooms at Air Base Hotel. Went into Oklahoma City for dinner tonight.

Dec 11 Wed. Oklahoma City. Waited for weather to lift. Unable to leave in time to reach Alamogordo before dark. At Air Base hotel tonight. Equipment from Johns Hopkins Unicersity transferred to MOGUL plane, including warhead of V-2. 4 scientists & crew, including Delgano? . Called Jimmie at Fairview, Okla.

Dec 12 Thurs. Left Oklahoma City in C-54 at 0800 CST. Arrived at Alamogordo about 11 RMT. Met Major Pritchard at air base. C-54 unloaded warhead material first then all MOGUL eqpt which went to North Hanger. Went over to Prichard's office, met Major Maguire? and talked over prospects of serûps. Woody and Phil worked on equipment pm. Went up in L-3 with Sgt Mack looking over country of proposed sites. WAC corporal launched at 4 pm. Worked on equipment tonight. Staying at BOQ.

Dec 13 Fri.Woody and I left Alamogordo Air Base in weapon carrier and scouted out area south of White Sands and Turoro Lake. Got lost on ordnance map we had. Located Tower and K station Went to Proving Ground. Saw Karsh and Major Grant and got good locations and one of good maps. Left Proving Grounds about 2 and went up west side of sand area to site A3. Arrived there at 4 but over very rough roads. Back to Alamogordo Air Base at 620. Chantz in Alamogordo working on T-21s, BST and Brush equipment.

Dec 14 Sat. Went out Hwy 70 this am toward Proving Grounds. Turned off at White Sands Nat'l Monument and drove to end of 9 mile road in park, about half in white sand area. Found location for #2 site which is about 30 miles north and a little east of launching site. Back to Air Base at noon. Went out north looking for Site 3. Tried to get through Ordnance Gate but needed key. Went back and around by Alamogordo and Tularosa but couldn't get in there. Back to base, got key from Provost Marshal and went out to Ordnance Gate. Found it did not lead in right Came back to North Hanger and took road out from there, finally landing at bombing area about 35 mi from base. Left all Rubicon equipment there. Back at Base 645

Dec 15 Sun. Got all GR3 recording units and went up to site 3. Set up both Rubicon in tent and GR3 in small building. Got recordings on both. Back through Tularosa and Alamogordo.

Dec 16 Mon. Signal Corps people, Dr Kane and Dr Crenshaw in this am. They are planning to measure time interval between bursts of meteorites at 60, 70, 80 seconds after launching. Went over our plans with them. Packed eqpt for Site #2 in White Sands. Chantz and I stayed setting up apparatus and Woody went back for equipment for Site #1. Left Site 2 about 3 pm and went to site 1. Set up equipment there. Finished about 7. To Alamogordo for dinner.

Dec 17 Tues. Got Chantz a Jeep to use on Station 3. Went out to #3 made final checks - Chantz stayed there. Woodruff and I went to Station 1 and made final checks there. Woodruff drove me to Station 2 and then went back to 1. V-2 rocket went up at about 1015 pm. Got Brush recording - 1 trace & Rubicon at 2. Woodruff got BST & Rubicon at 1 -though had interference with other group. Chantz got GR 3 & Rubicon record at #3. Back to BOQ about 12. Rubicon & BST recordings not yet developed.

Dec 18 Wed. Chantz and I went out to Sta 3 and got all equipment together and back to camp about 1 - went in borrowed weapon carrier. Woody and Jeff Fowler took other weapon carrier and collected all equipment from Sites 1 and 2. Packed all equipment at north hanger and loaded it into truck, which was then put on plane. Got data from V-2 firings from Pritchard's office. Left Alamogordo about 730 pm in C-54 and went to El Paso Biggs Field.

Dec 19 Thurs. Went down to El Paso this morning and then across to Juarez. Back to Biggs Field about 230 pm. C-54 left El Paso 400 pm , landed in Patterson Field, Dayton, Ohio 110am

Dec 20 Fri. Left Dayton about 9 am & arrived in Olmsted Field near Harrisburg, Pa about noon. Lt Carroll and Clowry drove us down to Pa RR station. Got 150 out of Harrisburg and arrived in Newark 6 pm. Caught train to Asbury Park.

Dec 21 Sat. Chantz went down to Oakhurst and developed 3 Rubicon recordings from White Sands and BST recording at Site # 1. Site #1 recording poor, possibly NG. Looked over recordings obtained at Oakhurst on bombing run of 19 Dec.

Dec 22 Sun. Out to Peoples this evening in Marlsboro.

Dec 23 Mon. Oakhurst. Worked on Alamogordo and Flight 13. Had flight # 14 this pm. - 24 bombs starting at 2 pm. Ran GR-3, Brush and Rubicon at lab. Woodruff went out to Farmingdal with van and Rubicon but results NG. No shots apparent on recordings.

Dec 24 Tues. Oakhurst. Closed down about 1130. Worked on Flight# 14 and work from NYU. Started Stepanoff on extension of Aug 8 flight. Into NYC PM and caught 1045 sleeper to NNY

Dec 28 Sat. Cold NE winds and storms all day. Unable to get roads cleared out. Cancelled reservations for this evening to NYC.

Dec 29 Sun. Caught 805 sleeper to NYC this evening.

Dec 30 Mon. Arrived NYC about 915 am - caught 1040 out of Penn Sta, arrived Asbury Park about 1 pm. Worked on Alamogordo results. Went over work with McCurdy who proposed new type instrument and wants authority to go ahead with it.

Dec 31 Tues. Oakhurst. Flight # 15 this morning at 1040 - 1105. Woody went out to Farmingdal and recorded on Rubicon drum. Recorded also on Rubicon drum T-9- Brush and GR3-T-8. Set up sonobuoy 1000 ft ± west of T-8-0. Times Square tonight.

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Jan 1 Wed Asbury Park. Snowstorm pm

Jan 2 Thurs. Oakhurst. Worked with V on flights 12, 13 and part of 14. Got Alamogordo results together. Conference this pm with Colonel Duffy and showed him my results with flights and with Alamogordo.

Jan 3 Fri. Oakhurst. Worked with V on Flights 14 and 15 and started NYU data of Sept 12. Stepanoff on extension of August 9 results. Conference pm: Dr. Ewing, Spilhaus, Dr Ference of Evans, Duffy. Discussed Evans program and air flight and Alaomgordo results. Made arrangements for cooperation with Evans in coming tests.

Jan 4 Sat. At Oakhurst about 3 hours. Finished getting velocities for Sept 17 flight and started work on data of Oct 4 cruise.

Jan 6 Mon. Oakhurst. Finished velocity data for Oct 4 and Oct 16 from NYU meteorological studies. Stepanoff finished Aug 9 data and started on # 1 of Sept 12. Moved into new building next to T-8-0 today.

Jan 7 Tues. Oakhurst. Vivian worked up ray paths, time and distance for Vel #2 of Sept 12. Started on Aug 8 data to get Stepanoff's figures together for study above 15 kms. Went scouting for location of sono buoy west of Oakhurst Arm about 3000 ft. Chantz and Woodruff on calibration of Alamogordo instruments and fixing up of equipment for field uses.

Jan 8 Wed. Oakhurst. Worked on Aug 8 cruise, making final calculations for sky wave. " on Vel #3, Sept 12 cruise. Woody and I went over to high ridge 2900 ft west of Oakhurst with sonobuoy which worked into GR3.

Jan 9 Thurs. Oakhurst. Worked on sky wave data. Vivian and Stepanoff on Sept 12 ray paths. Flight # 16 at 1200 to 1220 pm. No noticeable results. Used sonobuoy at 160' hill back of labs.

Jan 10 Fri. Oakhurst. Into Watson Labs at 9 to take supervisor's test. Trakowski, Peoples and I went to Camp Evans and discussed results of V2 rocket recordings informally. Flight #17 this PM 1600 to 1620. Worked on sky wave data

Jan 11 Sat. Oakhurst. Worked on sky wave data of Aug 8. Drew up curves for lower and upper stratosphere. Regung? brought in calculator from Wright Field.

Jan 12 Sun. Oakhurst. Worked on sky waves Aug 8th and 9th. Got out letter to Gutenberg pertaining to those two days.

Jan 13 Mon. Oakhurst. Working on sky wave curves. Made plans for Alamogordo this Thursday

Jan 14 Tues. Oakhurst. Calibrated instruments A-21 to take to Alamogorso. Raining

Jan 15 Wed. Oakhurst. Started writep of V-2 rocket work. Dr O'Day in from Watson and we went over V-2 rocket program with him. Finished calibration of T-21s on GR 8. Vivian finished sky wave curves. Worked on Dec 31 Woods Hole recordings.

Jan 16 Thurs. Oakhurst. All equipment for Alamogordo packed and loaded on truck pm. Worked with Vivian on sky waves of Aug 8th and 9th.

Jan 17 Fri. Oakhurst. Conference with Capts Lewis, Clowry and Duff of Olmstead Field and ACCUL at 1230 regarding bombs, future flights, etc. Mathematecian from Newman's group started work this noon - for two weeks. - working with Vivian. Woodruff and Chantz went up to Newark with equipment and loaded on P-47. Went up at 2 pm by staff car. P-47 left Newark 333 pm, landed at Patterson for fuel, landed at Tinker Field, Okla City 120 am. Stayed there overnight, Officers Manjak and Layden.

Jan 18 Sat. Left Oklahoma City about noon and went as far as Amarillo. Stayed at Amarillo - at Clinton Hotel

Jan 19 Sun Left Amarillo about 1130 CST - arrived Alamogordo 1230 pm RMST. Unloaded equipment off plane and put in north hanger. Unpacked GR-8s, T-21 galvanometers. 3 T-21s and 2 galvanometers broken. Repairing tonight

Jan 20 Mon Alamogordo. Tested out T-21s at north hanger with GR-8s. Loaded up all equipment for GR-3 and Rubicon drum and went out to A1 tower. Set up house along road about 3/4 mi southeast of the tower. Ran out 3 1000' lines for the at 120° radii. Set up dark room tent and 2 galv L&N broken suspensions. Worked on timing circuits, T-21s and galv at Alamogordo Air Base.

Jan 21 Tues Alamogordo. Tried out more T-21s with GR-8. All OK but one. Set out Site 2 near Hwy 70, C&GS marker 'Dona'. Laid out 1000'cables, set up Rubicon. Went out to end of Doppler line to station G but could not find C&GS marker 'Town'. Went back along line toward blockhouse & set up site #1, cables and Rubicon drum at intersection of G line and O line. Sites now set up 6, 13, 19 mi from blockhouse, all about 2 mi east of N line from boundary? site

Jan 22 Wed Alamogordo. Made rounds of all 3 sites. Set up L&N at Site #3, & surveyed to tower. Took T-21s and GR-8s to Sites 1 and 2 and set them up ready to operate. Took Rubicon recordings at Site 1 and 3 to check galvanometers.

Jan 23 Thurs. Alamogordo. Left air base about 900am. Bombing postponed from 11 am to 3 pm. Went out to Site 3, surveyed to tower. Got GR-3 recordings. Left Chantz at Site 3 and went to Site 2. Woody left Site 2 and went to site 1. Bombing delayed by 15-30 minute intervals from 3 pm to 519 pm. Got good recordings at Site 2 . Both other stations lost to triangulation acc't radio communication though Woody had GR-8 operating but without directional instrumnets.

Jan 24 Fri. Alamogordo. Checked with Major Pritchard at base. Left about 830 and picked up all equipment from 3 sites. Surveyed Site #2 and made rough survey of Site #1

Jan 25 Sat. Alamogordo. Sorted out all equipment at north hanger. Left GR3, Rubicons and Sprengnethers. Packed up GR8's and other equipment and loaded in C-47. Carroll and Short in C-47 from Middletown. ready to leave tomorrow. Worked on Site 2 recordings pm. got azimuths and angles of ascent for 2 main explosions. Have high angle of ascent.

Jan 26 Sun. Left Alamogordo about 830 am in C-47, Lt Sherry of Alamogordo pilot. Landed at Scott Field, St Louis for gas & eats, and then to Patterson Field, Dayton, Ohio where we stayed overnight acct bad weather east of Pittsburg.

Jan 27 Mon. Left Patterson Field about 930 am, arrived in Newark near noon. Chantz and Woodruff left by train. I went to Oakhurst with truck and equipment.Arrived about 330 pm. Peoples going to Washington tomorrow to V-2 panel meeting with Trakowski.

Jan 28 Tues. Oakhurst. Worked up diagrams for azimuth and offset distances, also angle of descent from Site 2, Alamogordo. Went over recording, got about 20 recordings on first part but only 2 on down part.

Jan 29 Wed. Oakhurst. Worked on latter part of V-2 recording of Alamogordo. Got 2 recordings besides 2 large ones, but very poor. Worked up possible trajectory of V-2 rocket. Worked up future program for Alamogordo - Chantz & Oliva leaving about 10 February for semi-permanent work there. We are passing up Feb 6 rocket but starting on definite program following that.

Jan 30 Thurs. Plotted up angle of azimuth against angle of descent for V-2 recordings. Set aside this work for bombing runs. Worked on Flight 18 with Vivian. Started Eileen on calculations with Aug 8 and 9 data, reworking calculations doe before. Checked picks on Flight 18 - they appear to be sky waves though angle of descent is not regular.
Jan 31 Fri Oakhurst. Worked with Eileen on Aug 8 calculations. Finished up for both direct and reflected possibilities. Went over Flight 19 records. Found that all of these are sky waves.
Feb 1 Sat. Left A.F. for Philly on 940 bus, arrived at Marions apt about 1. Wayne back from work about 5. After dinner we went out to Newtown and stayed overnight.
Feb 2 Sun. Drove up to Sparta NJ with Marion and Wayne. Saw Dorothy, Joe and family. Nelson Steenland & family living there with them. Saw Worzels pm. Ed Douglas in tonight for few minutes. Joe took me over to Dover & caught 958 train, then 1120 out of Penn Station, Newark. Arrived AP about 1230
Feb 3 Mon Oakhurst. Peoples in Washington regarding balloon ascention in June. Made plans for flight 20 which was made this pm 1300 to 1320 in conjunction with instruments in blimp. Route just south of east, no results. Worked on sky waves from Flights 18-19.
Feb 4-5-6, Tues, Wed, Thurs. Oakhurst. Checked over all sky wave picks on Flights 19 - 19. Went over Loran data and plotted up to get accurate plane speed. Plotted T - X curve using these figures. Worked up Oakhurst corrcetions for elevations and replotted all values for velocity - Flights 18 - 19. Received Gutenberg letter in which he had worked out Aug 8,9 data. Went over this method and worked over thae data again. Unique solution not obtainable. Went over possible experiments in 'Helios' balloon June with Peoples.
Feb 7 Fri Oakhurst. Worked on 23, 24 Jan T-X curves. V files 23,24 Jan forms, started on NYU data. Eileen worked on least squares-Va , then on Gutenberg's method applied to Aug 9 data.
Feb 8 Sat Oakhurst. Worked on V-2 rocket information 23 Jan. Used meteorological informatior for 2 explosions. Tried to get $\bar{V}$ at height of explosions but seems too low.
Feb 9 Sun Asbury Park - worked on calculations of flights, setup? and calculations for rockets.
Feb 10 Mon Oakhurst. Worked over Alamogordo Radar Hueco stations for 23 Jan 1947 records and made plot of V-2 rocket D - H using all radar data. Went over all equipment to go to Alamogordo. Made plans for departure Thurs. Set up 8 sec galv in T-9. Vivian checked velocity from caps with temperatures and continued on Oct 22-23, Flights 12-13, Cruises, NYU data. Eileen in pm - worked on formulas of seismic refraction using straight line for line - Aug 8 - 9. Finished this and went back to least square solutions of Jan 23 -24 data.
Feb 11 Tues Oakhurst. Flight 21 scheduled for 8 tonight postponed until tomorrow. Worked on Oct 22 data with sky waves to Highland Lights. Went over all records. Have 2? consecutive shots to H.L. Oliva left by train tonight for Alamogordo.
Feb 12 Wed Oakhurst. Vivian & Eileen worked on temperatures and winds Oct 22 & 23 and worked up ray paths for sky waves to Highland Lights. All equipment for Alamogordo assembled and loaded on trucks for Watson Labs this pm. Flight 21 at midnight tonight. McCurdy, Chantz, Woodruff, Ball, Hom?, Rigny present. Dropped 20 bombs 1200 to 1237. No signals received, either sky or direct waves.
Feb 13 Thurs. Got special instruments for 1 cycle from McCurdy this AM. Drove up to Newark in staff car- Chantz & myself. Loaded B-25 this pm but could not get all equipment on -left 5 reels and box of equipment ? . Left Newark about 330, stopped in Middletown, Pa - Olmsted Field for 1 1/2 hrs to eat and gas plane, then left and landed at Godman Field outside Fort Knox, Louisville, Ky. Stayed at Officers Club tonight.
Feb 14 Fri Left Louisvilleabout 930 am. Stopped at Tinker Field, Ok City for eats and refuel then to Alamogordo. Arrived Alamogordo 430 pm - contacted Watson Lab and got truck. Unloaded all equipment from B-25 & took part of it to North hanger. B-25 crew:Lt Mosher, Lt Alberts, Sgt ? Oliva arrived Alamo. by train this am
Feb 15 Sat. Moved eqpt from north hanger across runway to stowage building. Checked T-21s on GR 8, Checked galvanometers, etc
Feb 16 Sun Alamogordo.Out to Tower and Dona sites & surveyed in instrument locations - 5 to be station(ed) in shape. Ran out field wire at Dona station.
Feb 17 Mon Alamogordo. Went out to Tower site and set up Springnether and GR3 equipment. Rubicon 500 ft from GR3. Took trial recordings on both equipments
Feb 18 Tues Alamogordo. Went out to Dona Site this morning. Set up GR8 then Phil took truck and went over to GR3 Tower site. WAC corporal shot off about 215 but with little slipstream. Recorded at Dona but Phil at Tower site never saw rocket. Waited at Dona until 6 pm. Phil had

not come so got rideinto Army base. Phil in later. Very windy for recording.

Feb 19 Wed. Alamorgordo. Got radios from Watrus of Signal Corps and got trip tickets for tomorrow. Ran test records on Rubicon at both sites and checked everything ready for tomorrow.

Feb 20 Thurs. Alamogordo. Out early to station at Tower. Left Phil off there and went over to Dona Site. Rocket delayed from 10 to 1119. Both stations got good recordings except 1 9T-NS on both WC. Worked on GR8 records tonight.

Feb 21 Fri. Alamogordo. Went to White Sands Proving Grounds with Pritchard, Magnir?, Sol & Phil this morning for V-2 critiques, 0930 to 1100. Canister from rocket unpacked? about 40 miles up and finally found this pm between El Paso and Alamogordo. No transportation back to NJ yet. Worked on GR-3 records today

Feb 22 Sat. Alamogordo. Worked on data all day today. Correlated between the Tower and Dona sites for several sources. Worked total travel times for ascents both Dona and Tower and got average velocities up to about 65 kms, velocity increases from about 40 kms up to 60. Average velocity at 65 kms is about 320 meters per sec.

Feb 23 Sun. Worked on detailing record from GR3. Added more and made T-D move up to 75 kms, giving velocity of about 420 m/sec at top. Phil and Sal went out and picked up equipment - T-791s and GR8 and checked all pickups.

Feb 24 Mon. Alamogordo. Waited for air transportation today but none available and may not be any until Thurs at latest. Worked on V-2 recordings, frequency and characteristic analysis - T-3. Sal and Phil out to Site at Dona and recorded WAC Corporal at 1400. Got some waves in about 7 minutes after it had left ground.

Feb 25 Tues. Alamogordo. Went out to Tower Site, surveyed in #6, took down shelter. To Dona Site, set up GR3 in shelter, surveyed in #6, went to launching site, about 2 -3 miles NW launching area. Phil went in to WSPR and got permission, Sal and I surveyed 1 site for use with WAC Corporal.

Feb 26 Wed. Alamogordo. Worked on GR8 records of 20 Feb V-2 rocket. This am Phil and Sal set up Sounding? site for tomorrow's W.A.C. I left 7 pm - C-47 Hoffman, Missinger: Pilot, copilot. arrived in Newark 9am.

Feb 27 Thurs. Arrived Newark 9 am. Lewis, Duff, Mosher a request? in from Middletown - on way to WL to conference and I rode in with them. Conference re future missions. Conference PM Trakowski, Peoples, Rying & myself regarding future operations

Feb 28 Fri. Oakhurst. Ewing in from NYC. Went over Alamogordo results with Ewing, Peoples and Trakowski. Out to Peoples tonight

March 1 Saturday. Asbury Park

March 2 Sunday Oakhurst. worked on calculations for wind translations.

March 3 Monday. Oakhurst. Postponed Alamogordo trip until tomorrow. getting together equipment for Alamogordo. Thompson going also to get information on bombing runs? there, Worked on calculations from V-2

March 4 Tuesday. Thompson and I left staff car about 930, arrived at Newark 1040. Loaded up B-25 with equipment and left about 1230. Stopped at Middletown and picked up radio. Stopped at Scott Field & Tinker Field for gas. Arrived at Alamogordo 2 am. Crew B-25: Hoffman, DeTurk, Hancock

March 6 .Thursday. Alamogordo. Snowing - rocket flight called off until tomorrow. Chantz out to Tower Site and brought in batteries. Sal and I checked low frequency equipment and went out to Tularosa site with it this pm. Ready to use on 1 sec galv on Rubicon drum

March 5 Wednesday. Alamogordo. Chantz, Thompson and myself out to Tulerosa site and surveyed out X setup and ran out wires. Back about 2. Oliva working on check of T21s. Worked on radio and T21s until tonight

March 7 Friday. Alamogordo. At 8 am Pritchard got word rocket would go off between 1034 and 1200. Phil and Sal went out to Dona and Launching Sites with weapon carrier. Hoffman, DeTurk and Thompson out with them in staff car. I took Jeep and went out to Tularosa site. Rocket off at 1123. Got recording on GR8 but not time for Rubicon record. Phil and Sal got OK records from their sites. Thompson reported on bombing sites for runs and met and talked with Ordnance Officer. Left Alamogordo 845 pm , B-25 with Hoffman, DeTurck. Motor trouble on way and reached? Tinker Field 1200 with cylinder broken.

March 8 Sat. Hoffman wired Alamogordo and caught Manjak & Schneider (P4)? before leaving for Florida. They changed their route and landed at Tinker Field, O.C. 535. Trouble with their oil gauge and the trouble not repaired until 10 am. Left Tinker Field 10 and landed at Patterson. Off from patterson to Olmsted, Olmsted at 9pm. I stayed there overnight.

March 9 Sun. Left Olmsted 0934 am - C47, Manjak and Schneider and landed at Newark 1130 Thompson and I took train to Asbury Park from Pa station. In Asbury Park 3 pm

March 10 Mon Oakhurst. Vivian and I worked on Flight 25, Parts 1 and 2. Started Eileen on V-2 rocket recordings.

March 11 Tues Oakhurst. Vivian and I worked on Flights 25, 24. Flight 26 off today, Part 1 at 9, part 2 at 2 pm. Good results! Eileen on V2 rocket March 7, Dona Site.

March 12 Wed Oakhurst. Vivian and I worked on records - Flight 26, and started Flight 23. Eileen worked on Dona site , V-2. Thompson and I went over Alamogordo plans.

March 13 Thurs Oakhurst. Worked with Vivian some on Flight 23 and 22. Worked on Tularosa site of V2 - 7 March. Eileen worked on Launching Site, V-2. Flight 27 today - at 12 noon and at 4 pm. Probably last of flights.

March 14 Fri Oakhurst. Vivian worked on identification of returns, last 4-5 cruises. gave good sky waves. Trakowski, Peoples and myselfwrote up report for General Reves on overall program to be hand carried by Thompson to Washington. Eileen worked on V-2 records, #21

March 15 Sat Oakhurst. Worked up survey of Launching Area and Tuleroso sites & plotted all sites on air map. Worked on V2 rocket March 7 records.

March 16 Sun Oakhurst. Worked on formula for sound correction until 2 pm - went over to McCurdys tonight.

March 17 Mon Oakhurst.Vivian plotted up all last sky waves. Worked on eqpt list for Alamogordo. Worked on formulas for wind correction.

March 18 Tues Oakhurst. Worked with V. Checked through all March 13 records. Worked on Woods Hole recordings pm. Eileen working on V-2 rockets.

March 19 Wed Oakhurst. Reviewed Flight 24A trying to get some azimuths from Oakhurst but records very poor. Reviewed records of Jan 23rd and started on stratosphere calculations. Eileen working on corrections Jan 20 V2 rocket from meteorological data. Baten? in from Florida Field Station, ready to go to Alamogordo next Tuesday.

March20 Thursday, Oakhurst. Went over final calculations for stratosphere data using seismic methods, of Jan 23 data with Vivian. Got V=325 at 3 kms. Studied azimuths on that data and got w = 10 m/sec coming from south on June 23rd. Worked with Eileen on rocket Jan 20thcorrecting for met data and plotting final H against X in kms from surface for up data.

March 21 Friday Oakhurst. Worked on Alamogordo plans - Lewis & Clowry over this pm and we went over all future plans including bombing for Alamogordo. Worked on rocket data with Eileen and on flight data with V, Stepanoff on ray paths of Dec 13

March 22 Saturday Oakhurst. Went over all V2 rocket data. Studied azimuth - elevation graphs & studied WAC Corporal of 3 March. Caught 534 train from Asbury Park - 1045 sleeper out of NYC

March 23 Sunday. At home. Arrived Canton about 9. Left on sleeper tonight about 8 pm

March 24 Monday. Arrived NYC about 7. At 0930 went up to Math Department at NYU - Washington Square. Met Mr Bennett of WL. Found that Dr. Courant would not be in until late and decided not to wait but caught 1040 train to Asbury Park. Went over shipment ready for Alamogordo and over work for Vivian and Eileen. Packing tonight.

March 25 Tuesday Truck at Oakhurst at 9 with scales - all equipment weighed - about 3500# total including TORRID. Edmonton, Reynolds, Thompson, Porter, Godbie? and I left about 10 and went through to Mitchell Field in staff car. B-17, Carroll, pilot -- co-pilot. Left Mitchel Field about 3 pm. High level winds - went southern route - stayed at Maxwell Field Alabama tonight. Thompson stayed behind waiting for B-45

March 26 Wednesday. Left Maxwell Field, Ala. about 9 and landed in Alamorgoro 3 pm

March 27 Thursday Alamogordo. Phil, Reynolds and I went out to Tower site, took in all wires, Pulled down tent and Rubicon equipment and took it over to new site west of Lake Lucero. Strung out wire, surveyed in site & set up Rubicon tent. Sal, Edmonson, Godbie?, Porter weighing in equipment in Alamogordo air base.

March 28 Friday. Alamogordo. Went out with Godlers, Porter to White Sands west of air base. Located site and surveyed it, put up shelter and set up GR3. Phil and Reynolds went up tp Tularosa site, Sal and Edmondson worked on GR8 and low frequency equipment. Thompson in with B-45 from Newark.

March 29 Sat Alamogordo

March 30 Sun Alamogordo. Phil and I went out to Dona site and picked up some equipment and then out to Lucero site. Set up Rubicon and took a record. Tried to get through to Tularosa site west of White Sands but couldnt find road.

March 31 Monday. Alamogordo. Chantz, Bill Godbee and Ace went out to E. White Sands and Tularosa sites to make final setups. Sal, Edmondson, Peoples and I went out to Dona site this pm and moved tent and Rubicon to #3 position and set up low frequency apparatus

April 1 Tues V2 Rocket #22 went off at 1310 this pm. Chantz and Don at Tularosa, Godbee and Peoples at East White Sands, Sal and Edmondson at Dona, Porter and I at Lucero. All 4 stations got good recordings though low frequency instrument at Dona did not work out.

April 2 Wed. Peoples, Major Magnur?, Thompson and myself went over to Lt Col McKenson's office this am regarding bombing runs. There are many difficulties with the bombing here, mostly that so many new groups have moved in and are setting up on the northern? range. Thompson and I went overto see Major Mitchell this pm regarding same matter. Wrote memo regarding proposed work to take to CO tomorrow. Peoples left on B-17 today. Don and Bill G went to Dona and Launching Area sites am and got all loose wires. Don and Bill E went to East White Sands and Tularosa pm and got inventory and brought back Rubicon and tent from Tularosa. Worked on East White Sands record. V2 made 85 peaks - down course. Porter worked on calculations pm. Sal and Edmondson took complete inventory and this pm worked on low frequency equipment.

April 3 Thurs. Oliva and Edmondson on low frequency equipment. All T-21s changed over to Stds. Edmonton and Bill G went out to Lucero and Dona, got inventory and brought back tent from Lucero.

April 4 Fri. Reynolds and I went out to Osurso? Range and located PB1 bombing range. Set up wires and did surveying. Chantz and Porter on computations April 1

April 5 Sat Alamogordo.

April 6 Sun. Checked clocks. Cleaned out hanger and emptied trash out at East White Sands

April 7 Mon Talked to Pritchard re 3rd car for tomorrow. Gave him memo of progress report for MOGUL project to date, talked to Lt Dyer of Signal Corps regarding   for tomorrow firing. Chantz and Bill went out to Tularosa and got that site ready. All equipment checked for tomorrow. Edmondston and Reynolds ran drum recording of McCurdy low frequency equipment at base. Porter and I worked on amplitudes and frequencys of all recordings April 1 firing and started calculations. Olive worked on calibration of GR8 recorder attenuation. Got 3rd vehicle and all trip tickets for tomorrow.

April 8 Tues. Ace and I went out 7 am to Osarco site. Arrived 9 and set up radio and T-21s. Rocket due at 11, delayed until 1710. Very windy then, all settings at 8. Ran 3 rolls but nothing came in. Chantz at Tulerosa alone - Godbee and Reynolds at East White Sands - Oliva and Edmonston at Dona - all sites windy but 3 closest ones got some signals.

April 9 Wed. Worked on yesterday's records. Made picks on Dona, East White Sands and Tularosa Found nothing on Oscuro site recordings. Don and Bill G went out to East White Sands site and took recordings with pistonphone to get GR3 attenuation calibration. Sal Olive left this pm for San Diego. Wrote letters to Vivian and Jim P tonight.

April 10 Thurs. Ace and Phil worked on rocket recordings. - azimuths vs elevation angles. Don and I went out to Tulaarosa Range and checked bombing sites - bombing range just north of Range Camp and another site between that and our Tularosa site. Triangulated in with Tularoas Peak, etc. Thompson left in 45 for East. Godbee and Edmondson went with him.

April 11 Fri. Don and I went out past Tularosa Site looking for bombing sites. Went back to Air to Ground Range and to air strip. Chantz and Porter working on calculations V2 23 and T-21 calibrations.

April 12 Sat. Alamogordo Air Base

April 13 Sun. Worked on formula for triangulation without using compass - Alamogordo Air Bas

April 14 Mon. Porter, Chantz and I worked on GR3 and GR8 calibration curves for frequency and attenuation settings. Don worked around equipment - Don, Ace and Bill got apartments at air base. Wrote letters to Vivian and Eileen tonight.

April 15 Tues Alamogordo. B-29 arrived today - Lt Ball, McCurdy, Woodruff and MOGUL personnel - 41493: Lewis, Wolk, Burnhoff, Adams, Duff . Worked some on instrument calibrations. Lewis, Ball and I checked with Major Pritchard, then to Major Mitchell's office regarding bombing sites. Mitchell said CO had turned down bombing from air, but we could have surface charges along Tularosa road. Went up in AT-6, light plane with Capt Runcraft and looked over area west of Tularosa as far as the mountains, where bombing sites are to be located.

April 16 Wed. Alamogordo. Chantz and Reynolds out to East White Sands and Tularosa sites to check GR3 equipment for tomorrow. Porter and McCurdy working on low frequency equipment for V2 tomorrow. Woodruff, Ball, Work and I went out to Dona site then to Launching Area site. Strung out wires and left equipment for tomorrow's firing. McCurdy working tonight on low freq. Oliva in from San Diego this pm

April 17 Thurs. V2 firing #24 scheduled for 11 am. Chantz - Porter at Tulerosa Range; Reynolds - Woodruff at East White Sands, Woodruff with low frequency equipment for 1 trace GR3;Oliva - Kabassa?, radio operator on B-29 at Dona Site, Bill Edmonston arrived by car from Florida about 11 and went out to Dona -- Captain Lewis and myself at Launching Area site. V-2 postponed from 11 to 1610. 9 explosives supposed to go off, SCEL, only 1 worked. Tularosa site - had bad instruments - had 3 working but in line; East White Sands - one short roll, then paper jammed; Dona Site OK; Launching Area site - OK for first 2 rolls, paper jammed on third roll. McCurdy set up low frequency in hanger, north side, and on Rubicon drum but recordings questionable - as SCEL radio transmitter interfered.
April 18 Fri. B-29 took off for Middletown and Newark about 730 from Alamogordo with all personnel that came down with it. Wrote Peoples a letter regarding split-up of equipment so that bombing runs could be continued on East Coast. Plans are to have Edmonston, Reynolds here with 2 sets and take Oliva, Chantz w 2 sites for the East. Set up equipments - Sprengnether & L&N galvanometers for Helgoland experiment & run equipment 1030 to 3 Pm. Checked over all recordings. Oliva and Reynolds out to Dona and brought in all equipment except wire.
April 19 Sat. Into El Paso with Bill E this am. Got reservations to Houston next weekend.
April 20 Sun. Worked on plans for bombing runs and V2 monitoring.
April 21 Mon. Alamogordo Air Base. Bill Edmonston and I went out to Tularosa Range and checked 2 bombing targets, and located third bombing site 7-8 miles west of A1, near alkali flats. Chantz and Porter worked on calculations V2 -#24. Sal worked on equipment. Don off today.
April 22 Tues. Alamogordo. Reynolds - Oliva out to East White Sands. Brought GR3 there in for overhaul. Worked up calibration of GR 8. Got curves for settings of 8 and for changes in attenuation. Talked to St. James, Ordnance Supply, re 500# bombs. Wire from Peoples - Godbee ready to come back - plane ready to come down this week. Sent return wire to hold plane off until after 1 May.
April 23 Wed. Alamogordo. Bill E. and I left Air Base at 0930 and drove to Roswell. Scouted out area between Roswell and Donali? but all irrigated farm lands. Finally back with finding suitable site, 129 miles from Air Base to Roswell. Chantz went Tularosa range GR3 back, Oliva and Reynolds checking GR3 in base, Datn?on calculations April 1 rocket
April 24 Thurs. Phil and Ace working on V-2 recordings April 1 and 8 getting and amplitudes. Sal and Don on GR3, Bill E. on clock checks. Saw Pritchard about Roswell trips, bombing. Saw Post Engineers and Major Mitchell.
April 25 Fri. Sal and I went to Motor Pool and got our driving licenses. Worked up sunshots for Tower and Dona sites, OK within 10 minutes. Bill E and Phil got timbers from scrap pile and went out on Tularosa Bombing Range to build shelters. Sal and Don working on GR3. Left Air Base 130 and left Alamogordo 3 pm. Got room in El Paso at Hotel McCoy.
April 26 Sat. Left El Paso on Continental Air Lines about 0930, went by way of Hobbs, Midland, Odessa, San Angelo to San Antonio. Waited there about 2 hrs and caught Eastern Air Lines out to Houston. Got in about 0630, took bus to Houston and taxi to see Donnie.
April 27 Sun. Houston with Donnie and family
April 28 Mon. Down to Sohio Geophysical office with Donnie and Roy Bennett. Went up to Abbott and Stansell about a car. Caught bus out to airfield 1020 and caught Eastern Air Lines to San Antonio, and Continental Air Lines to El Paso. Arrived El Paso 730 and caught train to Alamogordo, then bus to Air Base. Chantz, Oliva and Bill E. checked over L&Ns, got driving licenses and worked on calibration curves.
April 29 Tues. Alamogordo Air Base. Delayed trip to Silver City to talk over Signal Corps Communication with Peoples, Ball this PM. Went out with Don to East White Sands to set up GR3 and get it working. Lt Thompson in pm. Lt Stevens in on vacation trip. Sal and Bill E got low frequency equipment together and ran test with it at hanger. Possibility rocket will not be fired until Monday acct weather
April 30 Wed. Alamogordo. Phil and Don out to East White Sands and Tularose sites to get equipment ready for test tomorrow. Set up Rubicon at Tularosa. Sal and Bill E. went to Dona and Launching Area sites to set up equipment. All mikes got out ready for firing.
May 1 Thurs. Out at 2 am. Put up equipment for low frequency run at the north hanger. Out to stations in field - Thompson with Phil at Tularosa - Don and Ace to East White Sands, Sal and Bill E. to Dona and I went to Launching Area site. Rocket misfired at 050009 and all equipment of Signal Corps 'explosions' lost. Picked up equipment from Dona, Launching Area and East White Sands this pm. C-47 in this pm: Dubell, Mosher and Duff. Duff brought in 2 100# bombs with some TNT charges. Bill Godbee in from R.B.

May 2 Friday. Alamogordo. Assembled apparatus to go back to Watson Labs. Phil and Bill Godbee out to Tularosa and picked up all GR3 equipment. Duff, Mosher, Dubell and I went out to Tularosa Bombing Site #2 and shot off 2 100# bombs, using the TNT blocks alongside. All went off OK. Duff got box caps for use. Will cancel 500# bomb order and use just TNT blocks if possible. All equipment loaded on plane this pm.
May 3-4 Sat, Sun. Left Alamogordo about 9 am, Chantz, Porter and myself, 2 Signal Corps men along. Stopped at El Paso and went over to Juarez for pm. Left El Paso about 8 pm. Landed in Scott Field about 4 and found weather bad in East. Stayed at BOQ until 10. Left about 11 and arrived in Middletown, Olmsted Field, about 6. Weather bad in Newark. Stayed in Olmsted Field BOQ
May 5 Mon. Left Olmsted Field at 7 am. In Newark about 8. Trucks in about 11. Loaded equipment and sent to Oakhurst. Arrived Oakhurst about 230. Chantz left for Frenchtown fm Newark
May 6 Tues. Oakhurst. Worked with Vivian and Eileen on their calculations. Eileen working on several? Feb 20 rocket and Vivian on last flights from Oakhurst.
May 7 Wed Oakhurst. Conference am - Dr Delassos? and Leonard from UCLA. Went over T-21 calibration they had - also the results from Alamogordo. Conference pm with Mr--- from AMC Wright Field. Flight scheduled for tomorrow, balloons with instruments going up at Bethlehem - B-17 following balloons with recording equipment and B-29 dropping bombs eastward from Atlantic City.
May 8 Thurs. Oakhurst. Scheduled balloon flight this morning at 730. Mears and men from NYU at Bethlehem with balloons. Trouble with winds and instruments did not go up. Peoples, Moulton over to Middletown with recording equipment on B-17 following balloons. Had no trouble following them. B-29 started dropping bombs near Atlantic City about 8. Trouble with oil leak in a motor and B-29 had to jettison the bombs and return. Recorded at Oakhurst with Brush and GR3. Working today with Eileen on Feb 20 rocket - final ave velocity data
May 9 Fri Oakhurst. Worked on calculations - bombing runs and V2 tests Feb 20. Took sleeper out of NYC for Canton tonight.
May 10 Sat. Canton. Steve and Esther up from Syracuse for weekend.
May 11 Sun. At home. Took sleeper out of Canton for NYC
May 12 Mon. Arrived NYC and caught 0940 out to Asbury Park - then to Oakhurst. Saw Mr Emmons of NYU this pm regarding future flights both here and in Alamogordo.
May 13 Tues. Chantz and I went down to Cape May today with staff car and driver. Located suitable site for bomb recordings on road between Cape May Court House and Goshen. Surveyed out 5 pickup locations and took solar observations. Back in AP about 0800 pm
May 14 Wed - Finished checking up with Chantz and Oliva in regard to bombing runs on east coast. Run scheduled for 9 and 12 on Friday. Packed up all equipment from computing office to go to Alamogordo. Checked transit and rod to go to Alamogordo. Jappett?, new computer, in today. Started him out on work Stepanoff was doing.
May 15 Thurs Oakes, Stevens?, Oliva and myself to Fort Dix this am early. Loaded up C-54 when it arrived, with 229 boxes of TNT, about 12,000#. Carroll - pilot and Hoffman- copilot. Mears, Vivian and Eileen arrived laterand we took off Fort Dix about 1130, EDST. Arrived in Fort Worth about 9 EDST. Off again to Big Springs, Texas, where forced to stop account of weather conditions. Stayed overnight at Hotel Supples.
May 16 Fri C-54 arrived at Alamogordo from Big Spring about 930 MST. All TNT unloaded and put in dump. Vivian and Eileen got rooms at girls dorm, Mears and I at BOQ 25. Went over future program with Edmondson, Reynolds and Godbee. Vivian and Eileen in office this pm. Have office in Watson Lab Bldg. Checked out ready to go to Silver City Monday. Got car ready and gas for car. Checked transit and made from field wire chain for 125 meters. Mears and Thompson down to critique at White Sands and to see Capt Smith of Weather Service.
May 17 Sta. Alamogordo. Vivian, Eileen and I worked on May 15 rocket data. Plotted up azimuth angle against elevation angle for Dona and White Sands stations. Plotted azimuth against time for Dona site.
May 18 Sun. Alaomgordo. Worked on Dona record, May 15 rocket. Checked through picks - plotte elevation angle against time, calculated elevation and distance from bombing site using straight line plane between launching site and point of impact.
May 19 Mon Reynolds and I left about 0745 in weapon carrier for Silver City. Arrived at Giles National Forest Station about 1230. Got permission for site there and went along valley 16 miles, then back 5 and located site. Surveyed location, dug holes and strung wire. Back to ranger station and located ourselves on range map. Left Bayard about 630 pm. Back at Alamogordo about 1045 pm. Edmondson and Godbee out to record WAC Corporal at Dona site

but it was postponed until Thursday.
May 20 Tues. Edmondson and I left about 0845 in weapon carrier for Roswell. Arrived at Hagerman about 12. Went across Pecos R and found site. Surveyed in locations, dug holes and strung wires. Went over to Roswell Army Air Field, filled up with gas. Checked for room for Bill for Wed and Thurs. Back to Alamogordo about 730 pm. Godbee and Reynolds loaded up one weapon carrier, ready to leave tomorrow. Vivian working on weather data to send back to Watson. Eileen working on March 7 azimuth - elevation plots and checking picks.
May 21 Wed. Reynolds and Godbee left about 800 in loaded weapon carrier. Stopped at gate by SC Lt and had to unload on motor pool weapon carrier acc't bad tires and heavy load on other one. Left about noon for Silver City. Bill Edmondson picked up GR8 and left for Roswell in weapon carrier SC about noon. Got all equipment together for shooting tomorrow. Worked with V and E this pm. Eileen finished checking original data 7 March and started checking April 1 azimuths and elevation angles. V finished azimuths direct waves and started extension of weather data to 288, 18 kms fm sky wave data.
May 22 Thurs. Thompson and I out at 0730 to Ordnance dump. Sgt Rand met us there and let us in area. Picked up 17 boxes of TNT. Shot 1000 at Site 1, 1100 at Site 3, 1200 at Site 3 and 1300 at Site 1 again. Thompson left for El Paso to meet his family, in from Corpus Christi. Worked a little in office PM. Called up Silver City and Roswell tonight, changed schedule of tomorrow from 1100 last one to 1115. Checked AAF clocks over telephone.
May 23 Fri. Went out at 0530 and got sgt Rand. We went out to ammunition dump, picked up 16 boxes of TNT. Sgt Rand to field with me. Shot 0800 Site 1, 0900 Site 2, 1000 Site 3 and 1115 Site 1. Worked on theoretical calculations pm. Bill E in from Roswell about 5 and and Reynolds & Godbee in about 800
May 24 Sat. Went over with Godbee and unloaded his truck, hung his recordings to dry. Went over GR8 records too but didn't see any signals there. GR3 from Silver City has some good sky waves.
May 25 Sun. Tried to get into El Paso to catch train to Houston but Alamogordo train too late to make connections. Back to Alamogordo Air Base.
May 26 Mon. Worked on Tests 1 and 2 records today. No signals from Roswell - some thunder on 2 shots. 5 sky waves from Silver City. Vivian worked on records, Eileen on thunder recordings. Godbee worked am, Bill and Don off today.
May 27 Tues. Worked with V on tests 1 and 2, E back on rocket of April 1. Bill Godbee and Don out to Dona and set up GR3 for Thursday firing.
May 28 Wed. B-17 in from Watson with Mears, Hackman, NYU and Alden. They plan to fly test balloon tomorrow. Other gang with recording equipment, due to leave Watson Sat. Got everything ready for HERMES rocket tomorrow, Dona & White Sands. Finished theoretical calculations of T-X solution of sky waves.
May 29 Thurs. Mears and Hackman got balloon ascension off about 1 PM today with B-17 plane to follow it. Don and Godbee out to Dona, Bill and I to East White Sands to record HERMES. Set for 1100 am, postponed repeatedly, finally fired at 0730 PM. Rocket off course, landed near Juarez, Mexico.
May 30 Fri. Memorial Day. Got 330 bus out of Alamogordo, 1030 train out of El Paso to Housto
May 31 Sat. Arrived Houston 715, went up to bank 900, then to Abbott - Stansell and picked up car - '42 Chrysler. Went up to Sohio and talked to Donnie and Roy Bennett for an hour. Left Houston about 1145, stayed overnight past Post, Texas.
June 1 Sun. Left 0400, arrived in Alamogordo about 0930 - 800 miles to base from Houston. C-47 with Moore, Schneider and others from NYU. Also Ireland, Minton, Olsen. NYU men worked on balloons today in north hanger.
June 2 Mon. Changed shooting plans to coordinate with balloon flights. Balloon all ready to go. Receiver in plane and receiver on ground. Edmondson with GR8 to Roswell pm, Godbee and Reynolds with GR3 to Silver City. Vivian working on amplitudes of flights - Eileen on April 7 rocket.
Jun 3 Tues. Up at 0230 am ready to fly balloon but abandoned due to cloudy skies. I went out to Tularosa Range and fired charges from 6 on to 12, missed 530 shot - trouble getting ordnance man.
Jun 4 Wed. Out to Tularosa Range and fired charges between 00 and 06 this am. No balloon flights again on account of clouds. Flew regular sono buoy up in cluster of balloons and had good luck on receiver on ground but poor on plane. Out with Thompson pm. Shot charges from 1800 to 2400.
June 5 Thurs. Up at 4 to shoot 2 charges for balloon flight. Whole assembly of constant-altitude balloons set up at 0500. Fired charges at 0537 and 0552, then soon buzzed by plane

to return. Receiver at plane did not work at all. Ground receiver worked for a short time but did not receive explosions. B-17 and most of personnel out to Roswell - recovered equipment some 25 mi east of Roswell. Out at 10 this morning, got TNT and went out to range. Fired shots 12 to 18 every hour. Last of bombing tests this week.

June 6 Fri. NYU personnel getting ready for flight tomorrow. Conference about noon, Hackman with radiosonde, Olsen and Godbee with receiver to Roswell - also Smith on theodolite. Regular equipment in plane.Edmundson and Reynolds to operate equipment at labs - receiver with GR8. Worked on adopting GR8 this pm and this evening. Fired some shots pm at site #4 but no transmitter for sonobuoy. This pm put McCurdy low frequency amplifier in circuit before GR8 and have plenty of signal.

June 7 Sat. Balloon flight off about 530. Dribbler? broken on takeoff. Balloon was to 60,000'±, broke left balloons then train came down somewhere in mountains. Recordings at north hanger, and at Roswell but plane did not receive. Shot at 6, 630, 7, 730, 8 and 830 at site #4. Plane out to find balloons but no luck. All NYU personnel and John Adden off on B-17 - Lewis, Gallagher. Went over to Alamogordo with Ireland, Minton, Olsen and Mears but no train today - making reservations for tomorrow.

June 8, Sun. Rancher, Sid West, found balloon train 25 mi south of High Rolls in mountains. Contacted him and made arragements to recover equipment Monday. Got all recordings of balloon flights. Took Ireland, Mears, Winton, Olsen to Alamogordo to catch train this pm

June 9 Mon. Bill Godbee and Don Reynolds went out to Sid West's ranch south of High Rolls and broughtback recovered balloons- clock, 2 radiosondes, sonobuoy and microphone and lower part of dribbler. Bill Edmondson cleaning up hanger and sorting out equipment of NYU. Worked today on balloon records (GR8) from north hanger. No definite signals obtained. Took inventory MRs.

June 10 Tues. Bill G , Bill E and Don worked on equipment, repairing GR8, T21 mikes, etc. Getting ready for rocket Thursday. Worked on GR8 recordings from Hagerman, Tests 3,4,5,6. No signals obtained. Worked on balloon tests from Roswell - no signals. V on Gila R tests 3,4,5,6, Eileen on V2 amplitudes.

June 11 Wed. Bill Godbee and I went out to Tulerosa Range and located Site #5 for bombing, 24 mi N of Site #3 - roads bad. Laid out wire for shooting, Don and Bill E getting ready for rocket. Checked Rubicon records, all 3 sites.

June 12 Thurs. All rockets postponed until July 3 rocket of S.C.E.L. Bill E, Don, Bill G went down to El Paso and then SE along Rio Grande. Located listening site south of Clint, Texas and layed out wires and dug holes. Worked on bombing flights from Oakhurst.

June 13 Fri. Men off today. V worked on tests 3,4,5,6 Tularosa bombing. E on V-2 rocket amplitudes. I plotted T-X all sky waves and started reviewing March 11 and 17 records.

June 14 Sat. Bill E and family, Don R and family, V, E and I to Carlsbad.

June 15 Sun. Through Carlsbad Caverns and back to Alamogordo.

June 16 Mon. Men off today. Worked on eastern shore cruises, plotting T-X corrected to 68 kms & worked on apparent velocities and differences in azimuth.

June 17 Tues. Men left for Silver City and Febrero? near El Paso for bombing tests. Worked on Cruises.

June 18 Wed. Test 7 of Tularosa Bombing Program, Shots at 7, 930 and 1230. Men called in from field to check clocks. Weather poor - raining at all sites. E on V2 rockets, V Cruises.

June 19 Thurs. Test 8 of Tularosa bombing program, shots at 1600, 1830, 2100 , 2400. Weather poor - rainy at Alamogordo.

June 20 Fri Finish of Test 8. Shots at 0000 and 0230, Sites 1,3,5. Men back today. Godbee, Reynolds at Silver City got all shots, Edmondson at El Paso got 1 possibly 2. Looked over all Fabens records today. E on weather data, rocket firings,V on Tests 3,4,7 and Flights.

June 21 Sat Worked on GR8 records from Fabens - calculated azimuth and elevation angles - Fabens recordings and some of Silver City.

June 22 Sun. On trip with V & E - San Cruzes, Hot Springs, Carizzo

Week of Jan 23-28 Alamogordo Air Base. Men worked on equipment for sound ranging Monday and made arrangements for off base transportation, had to get some from Base Motor Pool; Bill G, Don R left am for Gila Valley and Bill E went to Fabens. Tests 9, 10 Wednesday 25 and Thurs, Fri 26-27. Test 9: 7-10-13-16-18 Sites 1-3-5-3-1. Went out with Sgt Rand. Contacted by telephone Wed night and Thursday. Shot 10 Thurs, Fri at 18-21-00-03-05. Out with Sgt Rand again. Men in Fri pm. Good results from west, but poor or nothing from Fabers. Looked over some of Fabens records Sat. V worked on Tests 7-8 getting all data, including amplitudes, then worked on Flights 1-27. Got met data for all flights up to 18 kms except Oct ones. Found one whole minute error in timing on 24A flight which now checks with others in March. E on new weather calculations 20 Feb. Found adding wind directly to velocity from temp gives accurate enough results. Changed 20 Feb rocket and plotted up altitudes against signal Strength - shows nothing significant & started on 1 April rocket. Have all 4 station azimuths about finished. Phil Chantz and Wiggett in by train Friday night. They brought in records of Flights 28, 29 and 30 on east coast - 1 of May and 2 in June. Went over records Saturday and identified signals of 28 -29. Balloon expedition personnel arrived Saturday evening - Peoples, Trakowski, Mears, Ireland, Olsen, Moulton, Alden from AMS and Moore, Schneider, Hackman, Smith, Hazzard, 2 others and a Lt Smith from Navy NYU.

29 June (Sun) NYU personnel and some of Watson Lab men working today with equipment in north hanger. Went to Ruidoso with Mears, Trakowski, Godbee, V & E

Week of 30 June - 5 July '47 Alamogordo. Vivian worked on Tests 9 and 10, finishing all upward data on GR3 recordings. Eileen worked on 1 April rocket, getting signal strengths vs altitude (corrected for weather data) and started on time calculations to get time of signal for correlation purposes. Appears likely that strength of signal is dependent on station factors rather than anything about rocket.

Balloon tests? 7, 8, 9, and 10 off this week. Test 7, slated for 1 July postponed until 2 July as equipment was not ready. 100 tanks Helium obtained from Amarillo Monday evening. Also radiosonde receivers set up by NYU personnel Monday but were not operable. Test 7 at dawn on July 2 with pibal 1 hr first following with theodlite. Winds were very light and balloons up between A air base and mountains most of time. Included cluster of met balloons. Followed by C-54? for several hours & finally landed in mountains near road to Cloudcroft. Before gear could be recovered, most of it had been stolen. Stations operating at north hanger, Cloudcroft and Roswell. Shots made unfortunately at Site #4 and picked up good from north hanger and from Cloudcroft for awhile. Nothing from Roswell. On Thursday morning 3 July, a cluster of GM plastic balloons sent up for V2 recording but V2 was not fired. No shots fired. Balloons up for some time. No recordings from Roswell as pibal showed no W winds. Balloons picked up by radar WL and hunted by Manjak C-45. Located on Tularosa Range by air. Out pm with several NYU by weapon carrier but we never located it. Rocket postponed until 730 Thursday night but at last minute before balloon went up, V2 was called off on account of accident at White Sands.Sent up cluster balloons with dummy load. Balloon flight #10 at dawn on July 5th. Had gone out in C-45 again with Moser and Dubell to hunt for balloon from Flight 8 but not since? we found them. C-54 went to El Paso and picked up single Smith plastic balloon and GM cluster plastic balloons. Flight 10 with single plastic followed from Alamogordo and Cloudcroft. Shot 8 shots from Site 4. Picked up most and lost signal at 845. Balloons ? more than 6 hrs although time clock had been put in to bring them down after 5 hrs. ? were picked up by ? C-45 as first flight out was delayed. Had special balloon at 7 with explosice charge which went off at 35,000 ft and at 745 but by that time the receiver had lost the signal. Followed by radiosonde series until after 1300. Cloudcroft off at 8 and doubtful about signals received.

Peoples and Trakowski up 4 July with Dr. O'Day of CFS to Alamo Tower ---- ? Solar Observatory the SCEL station. Schneider up with O'Day to check use as NYU station.

Alamoggrdo crew helped get helium, and did ground shooting of 2 July. Out July 3 at Dona and Launching sites at 2 pm and later at night.

Finished identification on Flights 28, 29 and 30 on east coast and made plans for Bermuda flights.

Unable to leave for home on 3 July as was planned and wired Donnie first part of week if he could change his schedule and go home folloeing week. Got wire back that he had decided not to make the trip.

July 6(Sun). Worked at office on flights and rocket data. Started on plans for speech 17 July meeting NYU - Getting ready for Flight 11. Plans are to put up Smith balloon with GM ? plastics + simple met balloon sonobuoy + balloon bomb.

July 7 (Mon) Alamogordo. Balloon Flight 11 A off at 0503. Big plastic with small auxiliary plastics. WL gear - radiosonde and dribbler. Followed with theodolite and receiver until about 11. Picked up on radiosonde receiver at Roswell and followed them.Finally came down (at 10,000 ' cap should have punctured plastic) near Hwy 70 between Roswell and Tularosa. Second balloon - met balloons with radio sonde up about 630. Third balloon with 2 1/2 # stick TNTand caps set by pressure element to fire at 35,000' up at 0630. Surface bombing at Site 4 from 545 to 845 at 15 min intervals. Ireland followed main receiver only about 3/4 hr but followed radio sonde about 3 hrs. 35,000' explosion off about 655.

Vivian got all instructions for completing work on Flights 1-30 and picked all records and filed. Sent off TWX re Bermuda Flight and wrote up memo on it. Worked with Eileen on

April 1 rocket plotting H-SS, H-T, SS-T.
July 8(Tues) Alamogordo. C-54 off about 1030 with 23 people - all NYU, WL including /, E, Godbee. Lt Thompson, Edmondson, Reynolds and myself left. Wote up report on East Coast Flights for Peoples.
July 9(Wed) Alamogordo. Worked today on balloon flights. Studied WL records of them briefly and wrote a memorandum to Peoples about results. Left in car this PM late. Flat tire between Roswell and Tularosa and stayed there.
July 10 Thurs. Changed tire and went into Roswell. Bought new tire. On to El Reno, Okla today. Stopped in cafe in Hereford, Texas and met Dannie Harns from UGC. Went up to office and saw Bob Cowder?, PC and Gene Conant, supervisor.
July 11 Fri. From El Rosa to Cherokee. Got note at Cherokee that Jimmie was at Tonkawa and went over there. Stayed tonight with J & family.
July 12 Sat. Jim, Pat , Vanessa along with me on way home. Got to Doolittle, Ark tonight.
July 13 Sun. to cabins in Ohio just out of Springfield.
July 14 Mon. To cabins near Geneva, N.Y.
July 15 Tues. Stopped at Syracuse. Got home about 230. Marion & her baby there.
July 16, 17, 18 At home. Drew in 4 or 5 loads of hay but land very wet and rains intermittently.
July 19 Sat. Marion and I left in Chrysler for Woods Hole to see Dorothy & family. Through Albany, Springfield, Providence. 463 miles 12 hours. Doc Ewing on Atlantic cruise. Worzel working on gravity at sea. Saw Geo Woollard and the Ryders. Woollard after Guggenheim fellowship for next year - positions at WHOI and Princeton are ? very satisfactory.
July 20 Sun. Saw men working with Worzel at WHOI, Pollak, went over to Vine's new house, saw Kit and Bump at their house, then out to Ewings, saw Midge & children, Anne and Mikey.
July 21 Mon. Went down to WHOI, saw Pollak, Bumpus, Worthington. Up 3rd floor and saw Emmons of NYU, who is finishing up some research work there under Ray Montgomery. Talked with Columbus Iselin for short time. Saw Gil Oakley. Marion & I left about 11 am. Went through Providence, Hartford. Crossed river at Hudson. Met rain last part of trip, not home until 130. Jim & family spent weekend with Steve and Esther in Syracuse.
July 22,23,24 At home. Drew in a little more hay from lot in front of barn but still raining quite often. Jimmie & family took Thursday PM train to Syracuse to catch tomorrow's plane to Wichita, Kansas.
July 25, 26,27 At hôme. Steve and Esther came up Sat night. Marion and I went to Watertown to pick them up at bus station at midnight. They left again Sun pm on bus from Canton. Chas Crary up from Canton Sunday PM
July 28,29,30,31,Aug 1. At home. Chrysle to Canton, change plugs, reline wheels - Rained hard first part of week then clear. Got in lots in back of barn, north of road and front of house.
Aug 2 Sat. Marion - Bunny and I left 1230 PM, arrived Marcellus about 5 PM. Ate dinner with Steve and Esther, left Marcellus 730 PM. Through Binghamton, Scranton, Stroudsburg, Easton. Arrived in Newtown about 245 am.
Aug 3 Sun. In Newton with Flaggs for dinner. Left Newtown about 5 PM. Arrived Jersey Coast. Got room on Hwy 35 near White Bite Shop.
Aug 4 Mon. Up to Oakhurst. Went over developments to date with Jim Peoples. Out to lunch with Lt Ball. This PM Chantz and I surveyed to Sonobuoy site.
Aug 5 Tues. Oakhurst. Worked on Aberdeen results - 2 failures - 1 direct wave. - Worked on Bermuda run # 2 - Oakhurst and started Bermuda #2 C.N.C.H., Peoples on vacation starting today.
Aug 6, 7, 8 Wed, Thurs, Fri. Oakhurst. Worked on Cruises 1 -28 with Vivian and Epstein. Checked over all recordings of Bermuda #2, Flight 32. Got sonobuoy survey calculated and worked up results of Flight 25 B which depended on sonobuoy signal. Started Epstein on weather data which Wiggett is working on. Wrote letter to Emmons with remaining work to be done there. Conference Wed pm with Clowry, Carroll, Dubell, Bernhoff of Olmsted regarding Bermuda and Alamogordo plans. Mr Mears put up balloons with equipment on here at Oakhurst. Reynolds and Edmondson in and working around lab. Worked some with Eileen on rockets.
Aug 9,10 Asbury Park
Aug 11, 12,13,14,15,16 Oakhurst. Wrote memo regarding Alaskan work and had copies typed up. Worked most of week on rockets. Plotted altitude against time of origin for April 1, 8 rockets but did not get identical graphs. Tried to vary distance to obtain similiar curves but this was not possible. Made plots of time vs SS and altitude vs SS in effort to correlate signals between stations. Correlated fairly good on 1 April but poor on 8 April.

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New York University
Progress Report [No. 7]
Constant Level Balloon, Section II
July 1947

PROGRESS REPORT

Covering Period from June 1, 1947 to
June 31, 1947

CONSTANT LEVEL BALLOON

Section II

Research Division, Project No. 93

Prepared in Accordance with Provisions of Contract
W28-099 ac-241, between
Watson Laboratories, Red Bank, New Jersey
and
New York University

Prepared by Charles S. Schneider

Approved by Professor Athelstan F. Spilhaus
Director of Research

Research Division
College of Engineering
July, 1947

II. ABSTRACT

The first successful, though nominal, constant level flight was made in a series of launchings at Alamogordo, New Mexico. Navy permission was given for New York University to purchase the Navy-sponsored polyethylene balloons from General Mills. This opens up the first source of large, light-weight plastic balloons. First delivery was made on the subcontract with H. A. Smith Coatings, Inc. for the 15-foot diameter heavy polyethylene balloons. Improved type ballast reservoir was designed and procurement started. Equipment was prepared for a second series of flights at Alamogordo in July.

III. a. PERSONNEL

The following men were hired:

Name	Duties	Qualifications
Dorion, Richard	Navigator, Craftsman	Former B-17 Radar Navigator. Undergraduate Mechanical Engineering Student.
Higgins, Robert L.	Equipment Construction	Undergraduate Mechanical Engineering Student. Army Instrument Mechanic at Oak Ridge.
Morrell, Paul	Equipment Construction	Undergraduate Engineering Student. Merchant Marine Engineer.

ADMINISTRATIVE ACTION

Clearance was obtained from the U. S. Navy for the purchase of plastic balloons from General Mills, Inc., Minneapolis, Minnesota.

b. COMMUNICATIONS

(1) Correspondence during this period was as follows:

Date of Correspondence	Address	Abstract	Answer
6/16/47	Mr. A. P. Crary, Watson Labs., AMC, Alamogordo AAF, N.M.	Forwarding check for equipment recovery reward	None required

Date of Corres- pondence	Address	Abstract	Answer
6/16/47	Mr. F. M. Cooper 959 Whittier Ave. Akron 2, Ohio	Specification of large balloon sent and appointment requested to discuss manufacture	Considering problem before mailing bid.
6/19/47	Contracting Officer, Watson Laboratories Red Bank, N. J.	Enclosing copies of Special Report #1	None required.
6/19/47	Mr. Douglas Rigney Watson Laboratories Red Bank, N. J.	Request for additional Army weather equipment	Being procured.
6/23/47	Chief of U. S. Weather Bureau Washington 25, D. C. Att: Mr. B. C. Haynes	Request for Big Springs radiosonde station to monitor Alamogordo flights	Active cooperation received.
6/23/47	Kollman Instrument Div. Square D Company Elmhurst, N. Y. Att: Mr. Paul Goudy	Order to modify dribble mounting and rate of flow.	Complied with.
6/24/47	WIRE Mr. O. C. Winzen General Mills Minneapolis, Minn.	Request 7 foot balloons have means of attaching shroud lines to carry load.	Complied with.
6/26/47	Mr. O. C. Winzen General Mills Minneapolis, Minn.	Order to ship remaining 7-foot balloons to El Paso. Request for estimate on ballast gripping devices.	Complied with. General Mills awaiting ballast sample.

(2) Conferences

The following conferences were held during the month of June:

Date	People Present	Where Held	Discussed	Conclusions
6/12/47	H. A. Smith, Messrs. Schneider, Moore	New York University	Manufacture of Poly-ethylene balloons for this project.	2 each 15 ft. diameter balloons would be completed by 1 July.
6/15/47	Dr. Peoples, Messrs. Ireland, Mears, of Watson Laboratories, Messrs, Schneider, Moore, J. R. Smith, Hackman of N.Y.U.	Watson Laboratories Red Bank, N. J.	Results of Alamogordo flights	Communications will be improved, next flight's set-up accomplished.
6/17/47	Mr. Paul Goudy, C. B. Moore	Kollsman Instrument Co.	Modification of the Ballast valve	
6/20/47	H. A. Smith, Messrs. Moore, J. R. Smith	New York University	Different types of solid ballast	Granular lead is better than sand or various powders.
6/25/47	Mr. Gordon Vaeth, Commander G. W. Hoover, J. R. Smith, C. B. Moore	Sands Point Office of Naval Research, Port Washington, L. I., N. Y.	Request for clearance on General Mills Balloons. Request f r Lt. H. F. Smith (USNR) to accompany project to Alamogordo.	Granted.

c. 1. GENERAL WORK ACCOMPLISHED

Field tests were conducted at Alamogordo Army Air Base during the week of June 1, using clusters of meteorological balloons. The primary object of these tests was to perfect handling and launching techniques for large flights and to check the operation of the various altitude controlling devices developed for this project. At the same time, the tests afforded the opportunity to carry aloft payloads of Watson Laboratories equipment. In general, while the flights were successful in the sense of carrying Watson Laboratory gear aloft for an extended period of time, difficulties and materiel failures encountered served to emphasize the unsatisfactory characteristics of meteorological balloon clusters. A technical report under preparation will contain discussion of the flights.

After the return from Alamogordo, the remainder of the month was occupied with preparations for a second field trip to Alamogordo Army Air Base for tests to be conducted in July.

Twenty-five seven-foot diameter 1 mil. thick polyethylene balloons were received from General Mills. One each fifteen-foot diameter 8 mil. thick polyethylene balloons was received from H. A. Smith, Inc.

A seven-man balloon crew departed for Alamogordo Army Air Base on June 27 to make the second series of launchings there.

The plastic ballast reservoir used for the first flights in New Mexico was too fragile to take launching stresses. An aluminum reservoir, mounted on legs containing a built-in filter was designed and a supplier was located. The capacity of the new reservoir is 5 gallons (30#) though it will weigh only 2 pounds. It is believed that the aluminum reservoirs if recovered may be used repeatedly.

2. Specific Problems

The greatest problem encountered during the field tests at Alamogordo was the unpredictable and highly variable effect of superheat on meteorological balloons. The unpredictable increase in lift of the cluster under the rays of the sun was as much as 25% higher than the initial lift. This in several instances resulted in the inability of altitude control balloon cut-offs to stop the ascent of the balloon train at the desired altitude.

The extreme low temperatures encountered at high altitudes apparently has considerable effect on the operation of electrical equipment used in altitude control.

In several cases squibs used for altitude control failed to fire at extremely high altitudes. It is believed that placing a small load on batteries may help keep cells warm enough to produce the necessary voltage at high altitude on future flights.

3. Limitations

The greatest factor hindering the progress of work is still the lack of available space at New York University.

d. METHODS OF ATTACK

Field tests at Alamogordo indicated that a Helios-type cluster is much superior to a long cosmic-ray type flying line in case of fabrication, handling and launching when it is necessary to use clusters. Therefore, this type of cluster where the balloons are all at the same level, will be used on all future multiple balloon flights.

Large plastic balloons have been obtained and will be flown at Alamogordo during the tests to be conducted in July.

e. APPARATUS AND EQUIPMENT

The main sand ballast-dropping device was improved as a result of experiments at Alamogordo by constructing the ballast tubes of aluminum rather than plastic, and by using stronger paper diaphragms as the frangible support for the ballast.

f. CONCLUSIONS AND RECOMMENDATIONS

Opinion has been strengthened that clusters of meteorological balloons will never be a satisfactory method of achieving constant altitude for long period flights. Various factors which weigh against the success of such flights are: the inherent vertical instability of extensible balloons; the rapid deterioration of neoprene under the rays of the sun (average 6 hour life); the complex set of ballast and lifting equipment required; the variable and indeterminate effects of superheat; and the difficulty of launching a long train assembly, even under the best conditions.

In general, equipment must be strengthened and higher safety factors must be used to withstand the strains of launching and the oscillations of the balloon train in flight.

One or more observation posts, downwind, are needed for Alamogordo releases; each post should have theodolite and radiosonde observers and equipment. Better communications between, and coordination of observation posts is vital for satisfactory tracking of balloons in flight. Aerial observation of the balloons greatly assists interpretation of performance data. Better radio transmission of data is needed from the balloon.

IV. FUTURE WORK

Plastic balloons have been obtained from both General Mills and H. A. Smith, Inc. and will be flown on the next field trip to Alamogordo in July. Arrangements have been completed to obtain as large a supply as is necessary of these balloons and tests will be conducted frequently to perfect a technique of maintaining a balloon at nominal constant altitude.

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New York University
Progress Report No. 4
Radio Transmitting Receiving and Recording System for Constant Level Balloon
[Section I]
April 2, 1947

COLLEGE OF ENGINEERING
NEW YORK UNIVERSITY

REPORT BY THE

ENGINEERING RESEARCH DIVISION

PROGRESS REPORT NO. 4

Covering Period from March 1, 1947 to March 31, 1947

RADIO TRANSMITTING, RECEIVING AND RECORDING SYSTEM FOR CONSTANT LEVEL BALLOON

Research Division, Project No. 93

Prepared in Accordance with Provisions of Contract W28-099 ac-241, between Watson Laboratories, Red Bank, New Jersey and New York University

Prepared by

Prof. Philip Greenstein
Project Director
Department of Electrical Engineering

Approved by

Renato Contini
Acting Director of Research

Research Division
College of Engineering
April 2, 1947

ABSTRACT

During the period covered by this report, work was continued on developing an FM transmitter. Tests were made on FM Radio Receiver R-2a/ARR-3 and Radio Transmitter T-1B/CRT-1 to determine their performance characteristics, and compare the results with the transmitter system under development.

Necessary field equipment was constructed and an antenna was erected in preparation for field testing of the completed AM transmitter. A duplicate model of the AM transmitter was constructed and built into a container with a battery pack and simulated signal circuit.

a. PERSONNEL AND ADMINISTRATION

No change

b. COMMUNICATIONS

None

c. GENERAL WORK UNDERTAKEN DURING THIS PERIOD

It was called to our attention by the Watson Laboratories, Oakhurst Field Station, that the FM radio transmitter T 1-b/CRT, which is a unit of Sonobuoy equipment AN/CRT-1, might have application in this project. Five of these transmitters were purchased from a surplus radio supply house. These units were tested for frequency stability under conditions of variation in plate and filament voltages. Deviation measurements were made at several values of plate voltage. These tests indicated that this transmitter would probably be unsatisfactory without a system of automatic frequency control. The receiver used with transmitter, R-2a/ARR-3, has an a.f.c. circuit incorporated. A receiver of this type was borrowed from the Oakhurst Field Station. Tests were conducted to determine the overall frequency drift which could be tolerated in the transmitter before returning became necessary. It was observed that as great as a ± 0.35 mc shift could be tolerated at the transmitter. Further tests on the transmitter showed that the frequency deviation varied with input plate voltage and that as the battery depreciated, an error would be introduced in any amplitude measurement. For a plate voltage change from 135 to 90 volts, a variation in detected amplitude of over 20% was observed.

Further tests on the FM transmitter being developed at this laboratory showed that the deviation was likewise a function of the applied plate supply voltage. This problem will have to be solved by improved circuit design before a suitable FM transmitter can be evolved.

In addition to the AM transmitter model already constructed, a second unit was built. This duplicate was installed in a cardboard container which also houses the storage battery supply and a blocking oscillator to supply an audio-frequency which modulates the carrier at 30 c.p.s. Plans and arrangements were made for testing this unit on a captive balloon.

d. APPARATUS

A battery box containing a metered circuit for constant monitoring of transmitter currents were constructed for field or blimp transmission tests.

An antenna approximately 150 ft. in length was erected on poles twenty feet above the roof of the Electrical Engineering Building for use in receiving signals during test flights.

e. FUTURE WORK

In view of the excellent characteristics of the automatic frequency control of the Radio Receiver R-2a/ARR-3, an attempt will be made to secure the circuit diagram of this equipment and employ its use in any FM receiver which might be used.

Further circuit investigation will be carried out to develop an FM transmitter which is free of the undesirable effects introduced by input voltage variations.

Field tests will be carried out on the AM transmitter using a tethered balloon and a blimp, if available. It is desired to obtain information about the operating range and difficulties which might develop with this transmitter.

Philip Greenstein
Project Director

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Interview
Col Jeffrey Butler and 1st Lt James McAndrew with Professor Charles B. Moore
June 8, 1994

Same as
Weaver Attachment 23

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Report [Selected Pages]
Holloman AFB
"Progress Summary Report on U.S.A.F. Guided Missile Test Activities"
August 1, 1948

VOL. 1 1 AUG. '48 NO. 10

COPY #

HOLLOMAN AIR FORCE BASE
Alamogordo, New Mexico

PROGRESS SUMMARY REPORT

on

U. S. A. F

GUIDED MISSILE TEST ACTIVITIES

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~~SECRET~~

NONRECORD

S-E-C-R-E-T

Vol I

1 August 1948

No. 10

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radar station was not troubled by this phenomenon due to its antenna directivity and elevation orientation of 60 degrees. It is believed that the intermediate loss of signal by the radar station is normal because of elevation pattern lobing produced by ground-reflection interference which is initiated by secondary antenna lobe transmission. Since this condition exists in the transmitting pattern, it affects both the radar station and its remote receiving station. Current effort is concentrated on improvement of photography and antenna orientation in preparation for additional tests.

b. Tracking Projects:

(1) Radar Tracking Set AN/MPS-6 - A letter was received from Watson Laboratories authorizing changes and modifications of the range circuits necessary for conditions as encountered at this location. The fore part of July was spent in achieving these betterments, and in the installation and orientation of an M-2 optical tracker to be used in conjunction with the MPS-6 and as a tracking aid.

Experimental tracking of three balloons furnished and flown by the Atmospheric Group was performed for the dual purpose of checking the signal return of the radar with various reflecting targets, and for precise position data of the balloon equipment for use by the Atmospheric Group. On 19 July, a 130 foot balloon carrying no radar reflector was tracked. Radar contact was made at a range of about 3K yards with signal return being above saturation on the scopes of the MPS-6. Tracking was automatic in Azimuth and Elevation and aided in range. Signal return remained above saturation until a range of 7K yards was read, at which point grass appeared on the scopes and signal to noise averaged about 4 to 1 out to a range of 23K yards where too frequent radar losses necessitated that automatic tracking be abandoned. This balloon was then tracked manually to a maximum range of 27K yards.

On 20 July 1948, a weather balloon carrying one kite type reflector was flown and tracked. Contact was made at a range of 3K yards, and signal return was above saturation at all times until a range of 10K was exceeded and grass showed only occasionally out to 24,360 yards. This balloon was obscured by clouds at a range of 33K yards, but tracking was continuous in automatic Azimuth and Elevation throughout its flight, and the maximum range read was 34K yards.

On 21 July, a 130 foot balloon, identical with the one flown on 19 July except for three kite reflectors being carried, was flown and tracked. Radar contact was made at a range of 1,510 yards. Grass first appeared on scopes at a range of 24.5K yards, and signal was above saturation to 30K yards. Tracking was continuous and automatic throughout the flight, and a maximum range of 121K yards was reached.

Permission to use the MPS-6 in tracking further V-2 missiles having been received, plans were formulated for operation in conjunction with the missile scheduled to be fired Thursday, 22 July and postponed until Monday, 26 July at 1100. Plans contemplated that the crew on the M-2 Optical Tracker would track visually at all times during the flight with their elevation and azimuth readings repeated on the antenna. The MPS-6 antenna was initially positioned in azimuth on the calculated bearing to the launcher and raised slightly above the horizon in elevation, with the correct range gated on the scopes and with a velocity of about 300 MPH set in the aided range motor and the motor initially stopped. It was further planned that when target echo would bloom on the scopes, the echo should be trued up in Azimuth, Elevation, and Range; and antenna control would be thrown to automatic with range followed manually until speed of the missile approximated the 300 MPH as set on the motors, at which time the video motor would be activated and range tracking thrown to "Aided." It was planned to throw antenna control to the M-2 Tracker only if target failed to show or if extended "loss" subsequently occurred.

During the half-hour period prior to the take-off, several random aircraft were noted in the vicinity of the launcher; and at X-5 minutes, one low flying aircraft was observed on the scopes at a range beyond the launcher directly in line with it and flying in towards the launcher.

Timing signals and the zero signal were received, and at about X plus 2 seconds the target "bloomed" on the J Scopes at the calculated range to the launcher (62,800 yards). This pip went almost instantly to far beyond saturation, and all grass disappeared from the scopes. The Azimuth and Elevation, and Range controls were centered on the target, and antenna control was thrown to automatic. Range started to slowly increase as did elevation with azimuth being stationary. The echo remained beyond saturation for about two seconds after automatic control was thrown in, at which time grass appeared on the scopes and the signal fell rapidly to zero and the antenna whirled off target at about X plus 6 seconds. Upon returning antenna to position manually, a strong target appeared at a range of about 2K yards outside the range gate, and believing this to be the rocket, this pip was trued up and antenna locked in "Automatic" and this target was tracked for a period of about 10 seconds or until it was noted that range was decreasing and elevation was stationary at the horizon while the M-2 Elevation repeater showed the optical tracker to be looking at approximately 50 degrees. Realizing that the target being followed was the aircraft noticed before take-off, antenna control was transferred to the optical tracker and left in its control until the M-2 crew lost the missile. During this time, no target was visible at any time and no further radar contact was made with the missile. However, slightly before the missile impact was heard, a cluster of small echoes were found at a

22

Interview
[Col Jeffrey Butler and 1st Lt James McAndrew with] Col Albert Trakowski, USAF (Ret)
June 29, 1994

Same as
Weaver Attachment 24

23

Report
Cambridge Field Station, Air Materiel Command
"Review of Air Materiel Command Geophyscial Activities by Brigadier General D.N.Yates, and Staff, of the Air Weather Service"
February 10, 1949

[redacted]

[redacted] 47

Copy 3

Review of Air Materiel Command Geophysical Activities by
Brigadier General D. N. Yates, and Staff, of the Air Weather Service

Cambridge Field Station
Air Materiel Command
Cambridge 39, Massachusetts

23

PROGRAM

10 Feb. 1949

I. Introduction

II. Tour of Geophysical Research Laboratories

a. Review of Facilities

b. Project Presentations

III. Discussion

DOWNGRADED AT 12 YEAR INTERVALS; NOT AUTOMATICALLY DECLASSIFIED. DOD DIR. 5200.10

EXCLUDED FROM [illegible]

[redacted]

[redacted]

Z-1081

[redacted]

PROJECT ABSTRACTS

I. TERRESTRIAL SCIENCES LABORATORY

Chief: Dr. James A. Peoples, Jr.

1. Project title: Acoustic Sounding of the Atmosphere

Project scientists: Dr. J. A. Peoples, Jr., Dr. Norman Haskell

Summary of In-Laboratory work:

When large explosions have occurred, it has been observed that the sound was heard locally, say up to 25 miles, and also at distances of 100 to 200 miles, but that nothing was heard at intermediate distances. This phenomenon can only be explained by assuming that the sound is refracted into the atmosphere over the intermediate observers and then is bent back down to the more distant areas. For this to occur the velocity of propagation must first decrease with altitude and then increase again to a value at least as large as ground velocity. This is due to a decrease of temperature up to the tropopause followed by an increase in temperature above that level. Winds also have an appreciable affect which can be determined from asymmetrical propagation.

Up to about 1946 most data on this phenomenon had been obtained by taking polls after accidental explosions had occurred. Zones of audibility were mapped out and general conclusions then drawn. Very little systematic work was done in which accurate travel times and other factors were obtained. Beginning in 1946 at these laboratories, a systematic study of these propagation anomalies were started. Sound ranging detectors were set up in arrays, so that the direction and time of arrival of compressional waves could be determined. Explosions were set off on or near the ground at ranges varying from 25 to 200 miles. Data has been taken which has resulted in the indirect determination of the temperature (sound velocity) structure of the atmosphere up to the stratospheric level. East-west propagation was first studied off the New Jersey coast. These tests show there is little or no regular diurnal variation, and that some annual variation in the temperature structure exists. High level winds are shown to be generally easterly. Additional tests have been made in New Mexico to determine the diurnal and annual variations of the temperature structure at that latitude. Some accurate observations of wind velocity are indicated by observations taken along a north-south line as well as an east-west line. Winter observations have been taken in the vicinity of Fairbanks, Alaska for information at very high latitudes. Observations have been taken near the Panama Canal Zone for additional information in the tropics.

The sounds produced by rockets launched at Alamogordo have been recorded with acoustic detector arrays located on the ground near the rocket trajectory. From data gathered in this manner, some indications of upper air temperature and winds have been obtained and much more accurate determinations could be made if the rocket trajectories were more accurately known.

 [redacted]

[redacted]

Additional details of the atmospheric temperature and wind structure can be obtained by placing microphones near the tropopause where the velocity of sound is at a minimum. To our knowledge, no one has ever tried such an experiment, and in order to do this new equipment had to be developed, since wind produces strong noise in any microphone it was obvious that the detectors could not be used on an aircraft, It was further believed that the noise level of an instrument placed on a constant level balloon would be far below that generally observed on ground equipment. Both a satisfactory constant level balloon and a light weight microphone and telemetering system has been developed in this laboratory.

Basic acoustic propagation information is now being accumulated from equipments launched at Eglin Field Florida. The sound for these experiments is obtained from high altitude (20,000 to 25,000 feet) bomb bursts. Sufficient data have not yet been obtained to justify complete analysis, but it can be stated that observed results generally agree with predictions based upon theory.

Observations of the travel times of waves from an explosive source has yielded a considerable amount of data on the temperature and wind structure of the atmosphere up to altitude of about 50 km (160,000 feet). The interpretation of the data has so far been based on geometrical wave theory, and leads to a variation of propagation velocity with altitude which is in reasonable agreement with other lines of evidence. There are, howecer, several observed facts which cannot be explained on the basis of the elementary geometrical ray theory, and require a more complete analysis in terms of wave theory. They are: --(1) the "zones of silence", that follow according to geometrical ray theory from the initial decrease of velocity with altitude, which do not have sharply defined boundaries; (2) the same apparent angle of arrival is often observed over a considerable range of distance from the source, whereas on the ray theory a given angle of arrival was associated with one particular distance only; (3) at large distances, the total duration of the signals recei[illegible] is very much greater than can be explained by ray theory, and the character of the signal received is that of a lon[illegible] train of waves of varying amplitude and frequency rath[illegible] a limited number of well defined transient pulses.

Preliminary studies indicate that all of these facts may be explained qualatatively by more complete wave theoretical analysis of the diffraction of wave energy into the regions that are zones of silence in the elementary ray theory, and furth[illegible] work, aimed at quantative treatment is in progress. Until an analysis of this kind has been carried through, one can not feel too much confidence in attempts that have been made to use long distance sonic and microbaremetric wave propagation data to deduce atmospheric temperatures at levels above the second inversion.

In addition to the theoretical approach to this problem, consideration is being given to the use of surface waves on shallow water as a model of wave propagation in the atmosphere. The velocity of surface waves whose wave length is greater than the depth of the water is a function of the depth, so that the variation of velocity with altitude in the atmosphere can be simulated on a thin sheet of water by suitable contouring of the bottom. Surface tension and visosity set at a lower limit of about 4 cm. to the wave lengths that can be used in such a model. With a water table about four feet wide simulating the atmosphere up to 50 km. a four centimeter wave length would represent a wave length in the atmosphere of about 1 mile, or a period of about fiv[illegible] seconds.

 [redacted]

Complementary Contracts:

a. Columbia University
No. W28-099-ac-82

b. University of California at Los Angeles
No. W28-099-ac-228

c. Woods Hole Oceanographic Institution
No. W28-099-ac-227
All contracts on: "Consultation and Assistance in Research on Atmospheric Acoustical Wave Propagation."

2. Project title: Development of Constant Level Balloons

Project scientist: Dr. James A. Peoples, Jr.

Summary of In-Laboratory Work:

The development of a constant level balloon was at first motivated by the needs of the acoustic upper air sounding program. As it has developed, this balloon is now a principal atmospheric probing tool in its own right. In order to develop this balloon several special devices have been invented. An Olland cycle pressure indicator, accurate to better than one millibar, has been developed. A device has been constructed which will deflate and bring down balloons in flight either by timing or by pressure activated mechanisms. A balanced flow control valve has been made which gives a constant flow of ballast material proportional to pressure change. Other accessories include a telemetering device to indicate the rate of ballast flow, minimum ballast flow, minimum pressure switches, barographs, and balloon tracking radio transmitters which can be picked up by an aircraft radio compass at a range of 100 miles or more. A sensitive intergrating vertical anemometer is now being developed which will aid in the interpretation of atmospheric oscillations.

A thorough investigation of balloon materials and fabrication methods has been conducted, and balloons have been designed suitable for use with the balisting mechanisms developed. Launching and operationsl techniques have been developed which permit the launching of balloons in winds up to 20 per hour. Good control of ascent rate and ceiling altitude has been obtained. Constant level flights of several hours duration are now routine and flights lasting up to 5 hours with pressure variations not greater then one or two milabars have been obtained. Simplified control which operate satisfactorily during the day or night are not adquate when sunset occurs during a flight. A system for maintaining constant level thru sunset has been devised and tested in a bell jar, but in actual flight tests have not yet been made. Temperature measurements have been made both inside and outside of balloons to show the affects of super-heat. Temperature measurements have also been made in instrument and battery cases during flight. Measurements to show the actual characteristics of control devices have been made on balloons in flight and simulated in the laboratory. This

[redacted]

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includes rate of ballast expenditure, diffusion, leakage, and stability of control.

By-product information of importance to meteorology or balloon flying techniques includes the following: Observation, measurement and theoretical analysis of high altitude atmospheric oscillations has been accomplished. These oscillations are several milibars in amplitude (as indicated on balloon baragraph traces) and the period of oscillation varies between 4 and 10 minutes. Air mass trajectories have been measured over ranges up to about 400 miles and have been indicated by the recovery of gear up to 2,000 miles from the launching point. Additional field tests on air mass trajectories are now being made.

Complementary Contracts:

a. New York University
   No. W28-099-ac-241
   "Development of Constant Level Balloon"

b. Melpar, Inc.
   No. W28-099-ac-429
   "Development of Balloon Telemetering System"

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New York University
Constant Level Balloons
Section 2, *Operations*
January 31, 1949

Technical Report No. 93.02

CONSTANT LEVEL BALLOONS
Section 2

OPERATIONS

Constant Level Balloon Project
New York University

Prepared in Accordance with provisions of Contract
W28-099-ac-241, between
Watson Laboratories, Red Bank, New Jersey
and
New York University

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Prepared by: Charles B. Moore, Project Engineer
and
James R. Smith, Project Meteorologist

Approved by: William D. Murray for
Professor E. N. Kemler
Acting Director of the Research Division

College of Engineering
New York University
31 January 1949
New York 53, New York

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Figure Number | Page Number

OPERATIONS MANUAL

I. INTRODUCTION

A. Purpose of Manual

This manual is designed to serve as a guide in the preparation, launching, and tracking operations of constant-level balloons. In the body of this manual, most of the discussion applies specifically to the 20-foot diameter balloon developed by General Mills, Inc. In Section IX, a brief description is given of the other sizes of balloons used for constant-level flight. The manual is based upon the experiences and investigations of the Constant Level Balloon Project, Research Division of the College of Engineering, New York University. The charts and tables which were developed to use for this work are included in Appendix II of the manual.

B. Principles of Altitude Control

For constant-level work, non-extensible balloons are used for three reasons:

(1) With a given weight of equipment, it is possible to determine before the release of the balloon, the maximum altitude which will be attained.

(2) Without special control equipment, it is possible to maintain a nearly constant altitude for periods from one to six hours, depending upon atmospheric conditions and floating level. Generally, it is not possible to extend such flights through a sunset.

(3) By adding altitude control equipment, it is possible to maintain the balloon at various nearly constant, predetermined levels for periods of much more than six hours regardless of the time of day.

II. GENERAL MILLS 20-FOOT BALLOONS

A. Description

General Mills, Inc. of Minneapolis, Minnesota, has developed a series of non-extensible, plastic balloons. These balloons are tear-drop in shape, made from extruded polyethylene sheet, 0.001" thick. Cells are currently produced with a diameter of 7, 20, 30 and 70 feet. The volume of the 20-foot cell is about 4300 cubic feet and its uninflated length is 38 feet. It is made up of 20 gores, heat sealed together in a butt weld. Along the seams thus formed, a special acetate-fiber scotch type tape (Minnesota Mining and Mfg. Co.,) is laid to reinforce the weld and to carry and distribute the load. These tapes converge to an appendix ring at the balloon bottom, to which the load harness is attached. By using this stressed tape design, much larger loads may be carried than the thin polyethylene alone could hold. To exclude air entering through the bottom, which is left open, an external skirt or appendix is added.

Figure 1 shows a 20-foot balloon ready to be released, with an external appendix in position. As the balloon rises, the lifting gas inside will expand until the balloon is full, whereupon the excess gas which was needed to make the balloon rise will be valved out. The full balloon will then float at a level where the buoyancy just balances the load. It will remain there until buoyancy is lost by diffusion of the lifting gas, or by cooling, as at sunset.

Neglecting minor effects, the amount of gas which is needed to just balance the load at the maximum or floating elevation would also just balance the load at any lower level, including the surface, although the balloon would be less than completely full at such a lower level.

B. Load Limits

For a given lifting gas, the altitude to which a balloon will rise is determined principally by the load it bears. With a 20-foot General Mills balloon, using helium, a payload of 40 pounds will reach approximately 46,000 feet and an 18-pound load will go to about 58,000 feet. Although the manufacturers recommend keeping the payload between 18 and 40 pounds, no trouble has been found in launching loads of as much as 70 pounds (37,000 feet) or as small as 4 pounds (67,000 feet).

C. Appendices

For highest altitudes and smallest sunset effects on a balloon, it is necessary to keep air from diluting the helium. To accomplish this, a check valve is required in order that helium may be valved when the balloon is full, yet air not be permitted to enter at any time. An appendix, consisting of a tube of balloon material, whose length is about 2 to 2½ times its diameter is used for this purpose, and is supplied as part of the General Mills balloon.

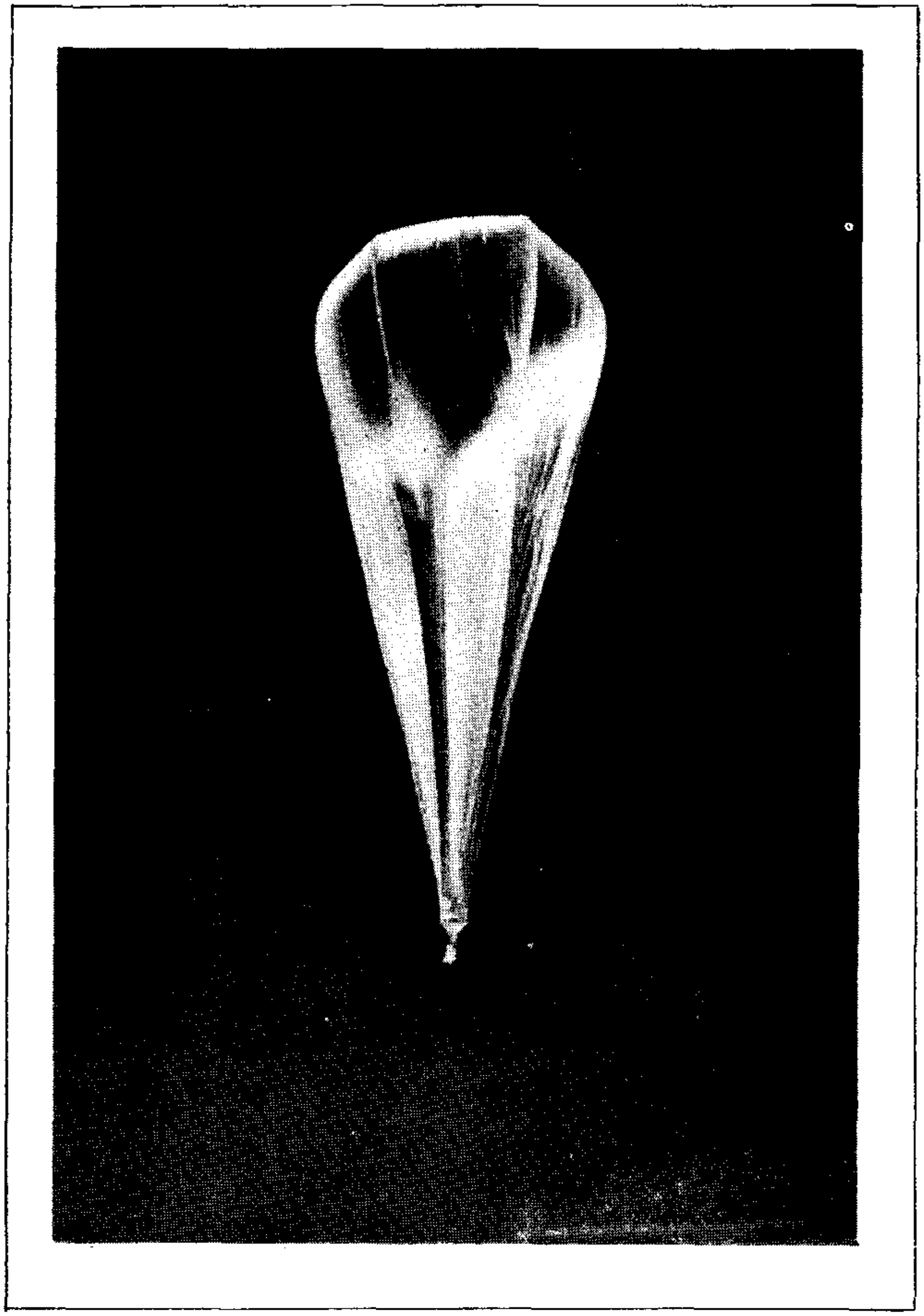


Figure 1
General Mills 20 foot balloon in flight with 2 foot appendix, stiffened with cardboard battens.

Stiffeners are added so that the appendix will not foul in the rigging. With a fouled appendix the helium cannot be valved, and the balloon after becoming full at its ceiling will burst. These stiffeners are taped to the outside of the appendix just before inflation.

The various appendix types which have been used are given in the following table:

Appendix Data

Appendix Type	Stiffeners	Effect on Altitude Attained	Effect on Descent
None	None	Ceiling is 10,000 to 20,000 feet lower than computed.	Balloon remains full at all times after ceiling is reached by taking on air. Greatly complicates control.
Standard	3 corrugated cardboard battens, $2\frac{1}{2}$" by 15"	Computed ceilings attained.	Balloon remains full at all times after ceiling is reached by taking on air. Greatly complicates control.
Standard	4 aluminum battens 15 x $\frac{1}{2}$ x .030" 24 ST	Computed ceiling attained if balloon does not burst due to restriction on appendix.	Air excluded during any descent fairly well.
Flattened Tube	Metal spring bow to hold appendix flat, like pressed trousers	Not yet flight tested. Similitude tests indicate computed ceiling would be reached with no bursts due to appendix at 1000 ft/min rate of rise.	Not yet flight tested. Similitude tests indicate almost complete exclusion of air.

Figures 2, 3, and 4 show the various appendices described in the above table.

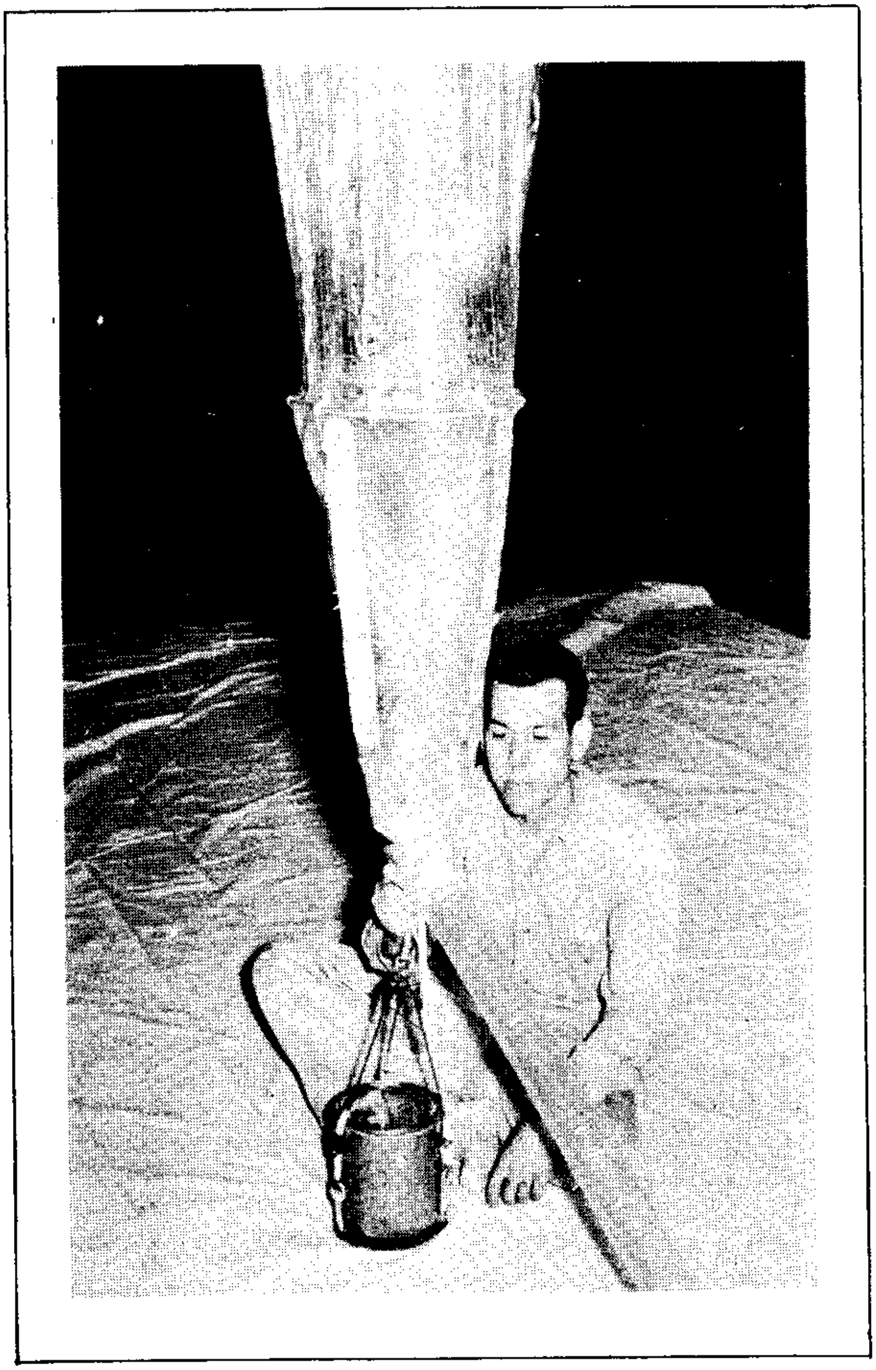
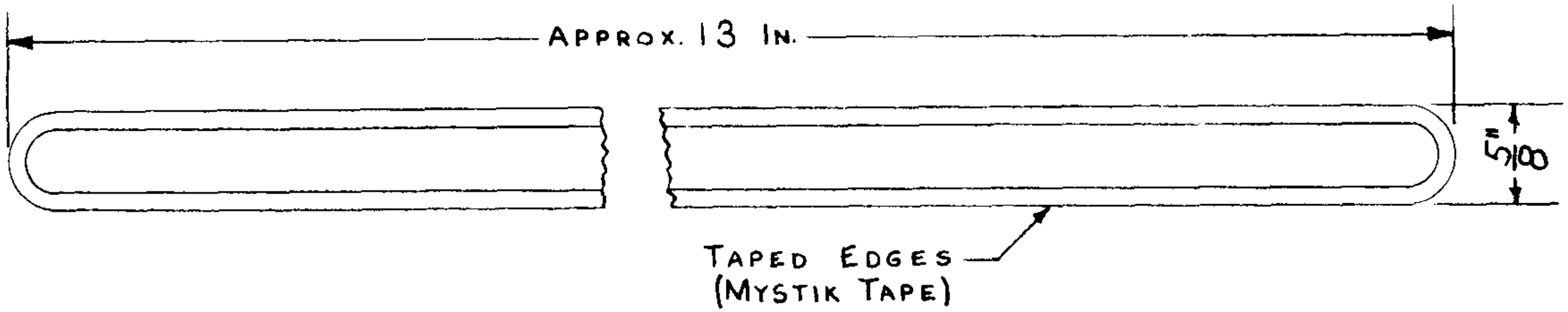
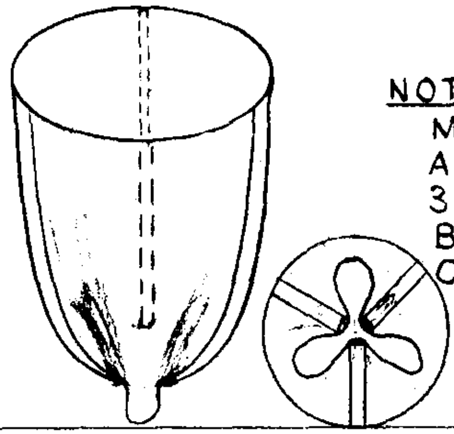


Figure 2

Two foot appendix, stiffened with card-board battens, shown on a General Mills balloon. The swollen inflation tube indicates that the balloon is being filled.





NOTE:
MAT'L: 17ST OR 24ST. AL. SHEET-.032 THK.
ALL EDGES TO BE COVERED WITH TAPE
3 BATTENS, 120° APART
BENT IN FIELD TO FORM LIGHT
CLOSURE OF APPENDIX

FIG. 3

BATTENS FOR G.M
20 FT. BALLOON
DWG. BY LHM
DATE 10-14-48
ED48-95A

Figure 4
Two foot appendix, showing
metal spring bow in position.

Since the back pressure forcing the helium out of a full balloon when it is rising is 4 times as great at 1000 feet per minute as at 500 feet per minute, the rate of rise is critical when an appendix is used. It has been found necessary to limit the rate of rise to 700 feet per minute to prevent bursting at ceiling when using General Mills 20-foot balloons with standard appendix. It is believed, from laboratory tests, that use of the spring bow stiffeners on the new appendix will permit rates of rise up to 1000 feet per minute. Flutter in the balloon fabric while rising is apt to cause failure due to ripping at speeds of more than 1000 feet per minute. A 20-foot General Mills balloon will burst with an internal pressure of 0.014 psi., which is about 1 mb., equivalent to a 200-foot rise at ceiling with a closed appendix.

III. EQUIPMENT TRAIN

A. Lines and Rigging

Following rigging failures early in the testing program, careful study was given to the lines and rigging methods used to attach flight instruments to the balloon. For safety in launching, a factor of 10 to 1 is used on all loads. Thus, if a 40-pound load is to be lifted, it is not safe to use less than a 400-pound tested line. The line strength should be determined independently if possible, since the actual breaking point of lines runs between 50 and 70% of the manufacturer's rated strength.

Braided or woven nylon is recommended for all rigging. A stranded or laid line is subject to untwisting in flight, twirling the suspended instruments and reducing line strength. The nylon material is weather resistant to a high degree and tends to stretch under shock rather than to snap. For some purposes it may be desirable to use a line of constant length, in which case the nylon may be prestretched. Only a few of the common knots are useful in tying nylon. Bowlines and square knots have been found to slip and are hard to untie. The carrick bend, shown in Figure 5, is recommended. In addition to this, a safety knot is made in the loose end, and the entire tie secured by a final taping. For convenience in assembly, the individual pieces of line and equipment are rigged with harness snaps at each end. This permits unit replacements or removal at the last minute with a minimum of delay. For extremely light-weight rigging, wooden toggles and loops in the nylon may be used instead of the heavier metal snaps.

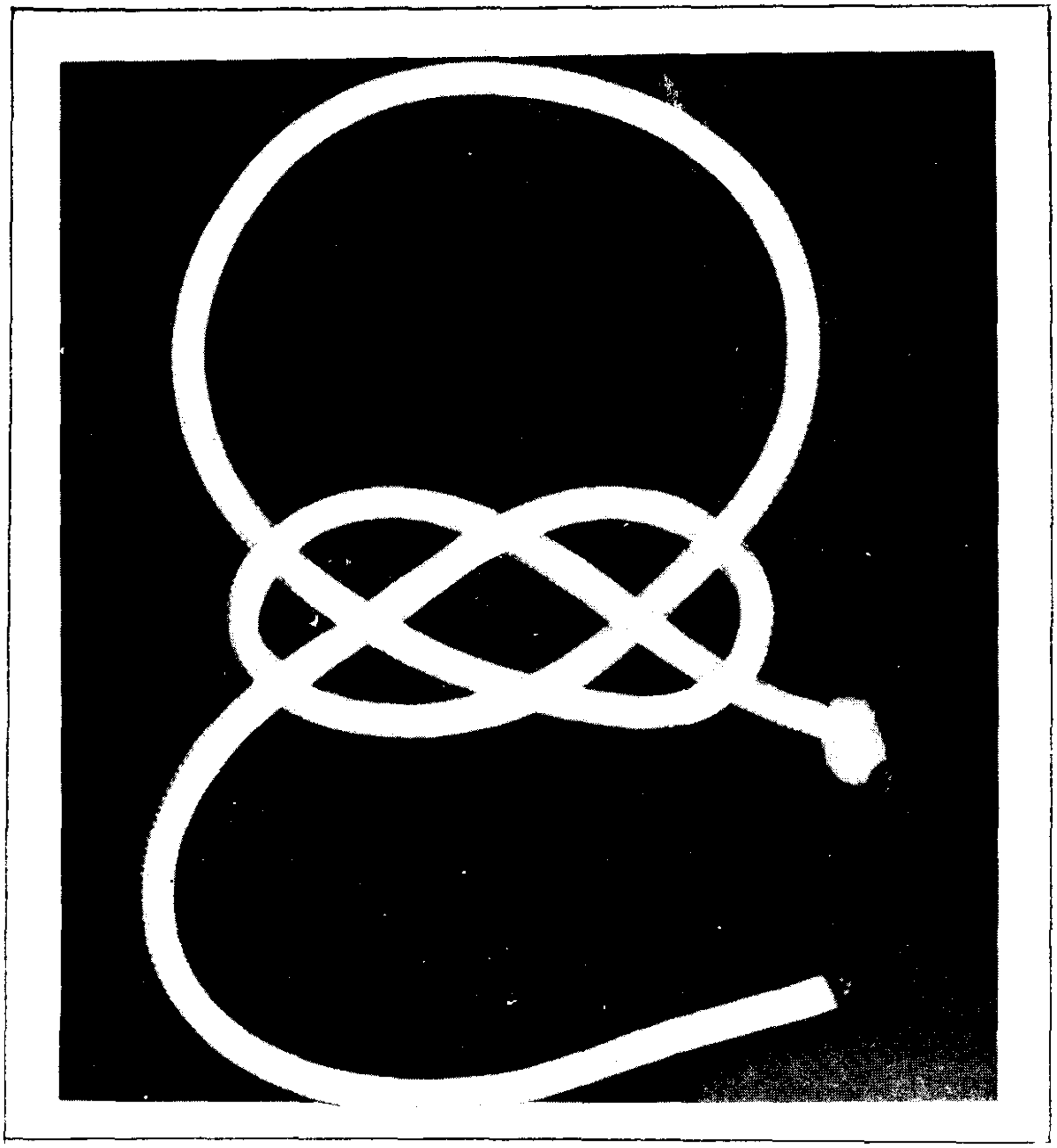


Figure 5

Carrick Bend

B. Altitude Control Equipment

Flights of 20-foot General Mills balloons, using no control equipment, have been sent to altitudes of about 50,000 feet. After reaching maximum altitude, the balloons all exhibit a tendency to float then descend at an increasing rate for periods of from 2 to 6 hours. In stable layers of air such as the stratosphere the descent of a balloon is retarded by the helium, on compression, getting warmer than the surrounding air. This results in much longer duration flights requiring no external control though, strictly speaking, the altitude is not constant. This concept is in good general agreement with the observed data; balloons have remained in a semi-floating state much longer (up to 30 hours) when in the stratospheric inversion than when in less stable lower atmospheric layers.

When it is desired to maintain a balloon at constant level for a guaranteed period of time in excess of two hours, a ballast system of altitude control should be added to the flight gear. The level at which the balloon is to float must be the maximum altitude to which it can carry the payload. To compensate for loss in buoyancy occasioned by loss of lifting gas through diffusion and leakage, a continual lightening of the load is required. To effectthis in a simple fashion, liquid ballast is permittted to flow through an orifice at a predetermined rate which exceeds the expected loss of lift. (See Section IV, D) The reservoir and ballast assembly which has been developed for this use is shown in Figure 6. A detail sketch of the orifice in its mounting is shown as Figure 7, and Figure 8 shows a suitable filter which must be used to protect the orifice from clogging. The liquid ballast must (1) not freeze, but flow well at cold temperature (-80°C); (2) not absorb water, which would freeze; and (3) be relatively inexpensive. A recommended liquid is Aeromobil Compass Fluid, made by Socony-Vacuum Co. (Air Force Spec. AN-C-116).

There are three possible objections to the use of this simple control system. First, a continued lessening of the total weight on the balloon--with no change in volume--must result in a constantly rising ceiling. For a 20-foot balloon at 45,000 feet, this change is approximately 1000 feet with each kilogram of ballast dropped (see Section IV, E). Second, only a prefixed ballast flow is permitted, and excessive loss of lift, as might come when the gas is colled at sunset (when the balloon loses superheat,

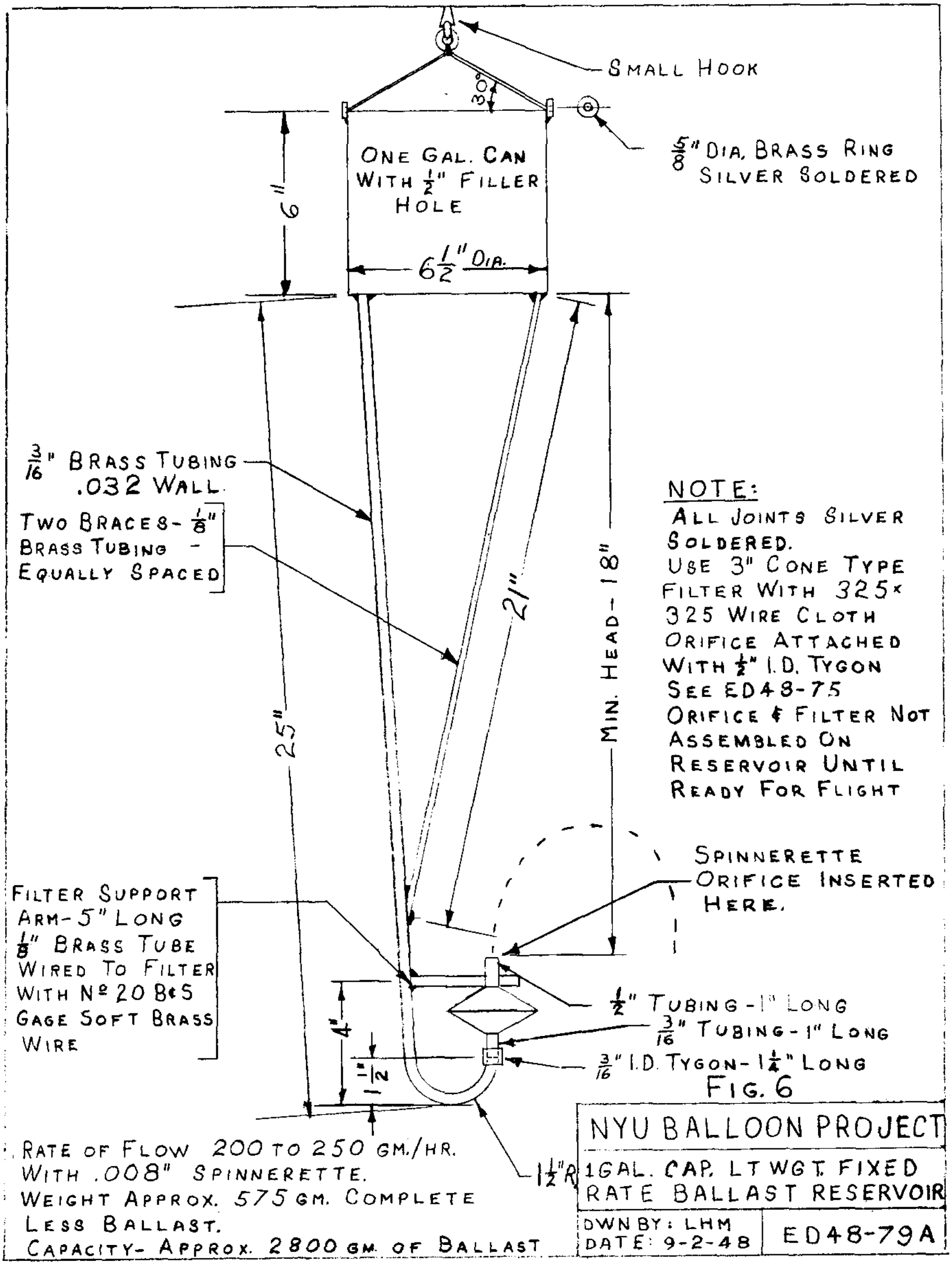

SMALL HOOK
30°
5/8" DIA. BRASS RING
SILVER SOLDERED
ONE GAL. CAN
WITH 1/2" FILLER
HOLE
6"
6 1/2" DIA.
3/16" BRASS TUBING
.032 WALL.
TWO BRACES - 1/8"
BRASS TUBING -
EQUALLY SPACED
21"
25"
MIN. HEAD - 18"
NOTE:
ALL JOINTS SILVER
SOLDERED.
USE 3" CONE TYPE
FILTER WITH 325x
325 WIRE CLOTH
ORIFICE ATTACHED
WITH 1/2" I.D. TYGON
SEE ED48-75
ORIFICE & FILTER NOT
ASSEMBLED ON
RESERVOIR UNTIL
READY FOR FLIGHT
SPINNERETTE
ORIFICE INSERTED
HERE.
FILTER SUPPORT
ARM - 5" LONG
1/8" BRASS TUBE
WIRED TO FILTER
WITH Nº 20 B&S
GAGE SOFT BRASS
WIRE
4"
1/2"
1/2" TUBING - 1" LONG
3/16" TUBING - 1" LONG
3/16" I.D. TYGON - 1 1/4" LONG
1 1/2" R
RATE OF FLOW 200 TO 250 GM./HR.
WITH .008" SPINNERETTE.
WEIGHT APPROX. 575 GM. COMPLETE
LESS BALLAST.
CAPACITY - APPROX. 2800 GM. OF BALLAST
NYU BALLOON PROJECT
1 GAL. CAP. LT WGT. FIXED
RATE BALLAST RESERVOIR
DWN BY: LHM
DATE: 9-2-48
ED48-79A

FIG. 6

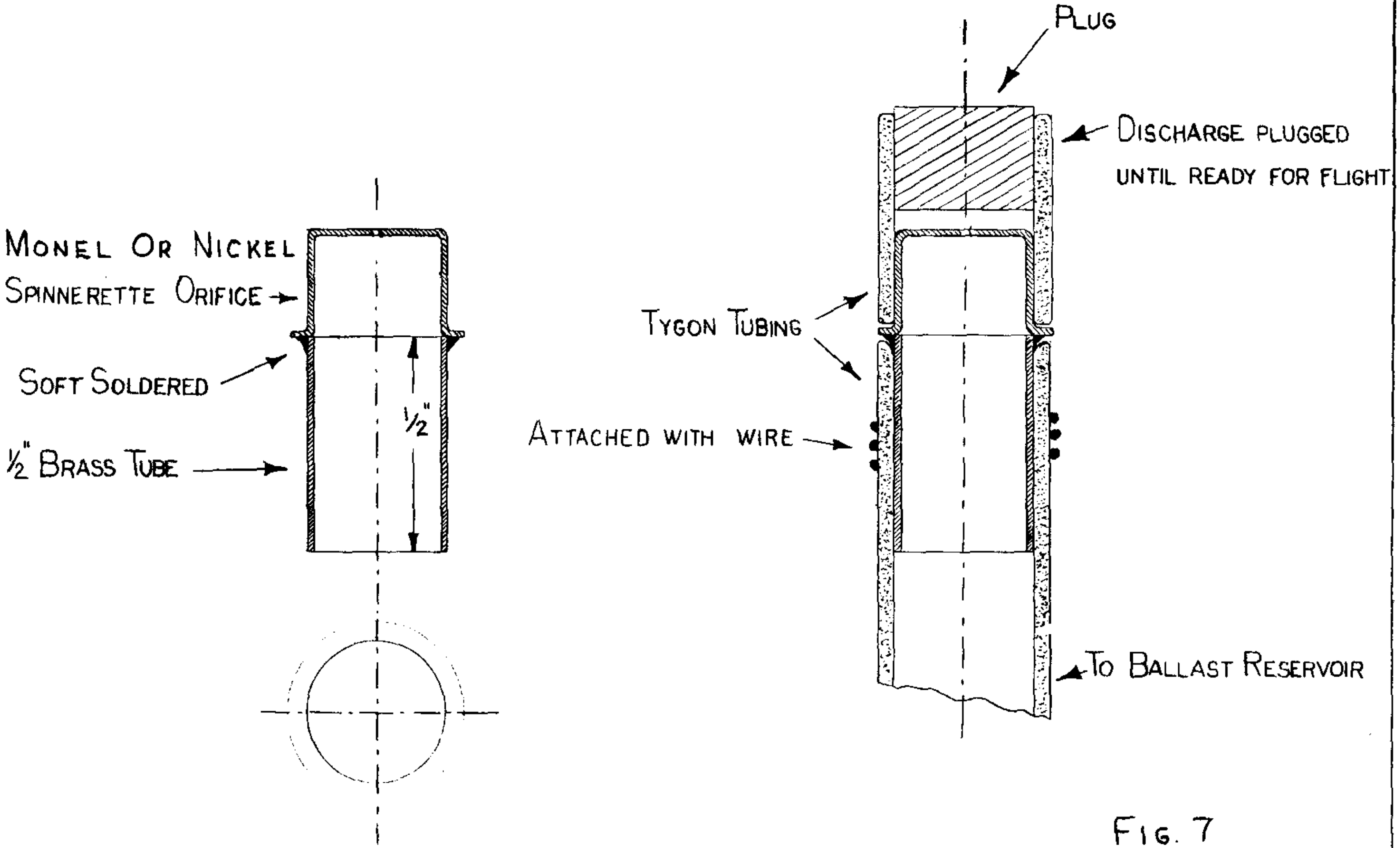


Fig. 7

NYU BALLOON PROJECT	
Orifice Assembly	
DATE 8-25-48	ED48-75A

Note
Spinnerette Orifice Mfd. By J. Bishop Co., Malvern, Pa.

JN

SECTION A-A

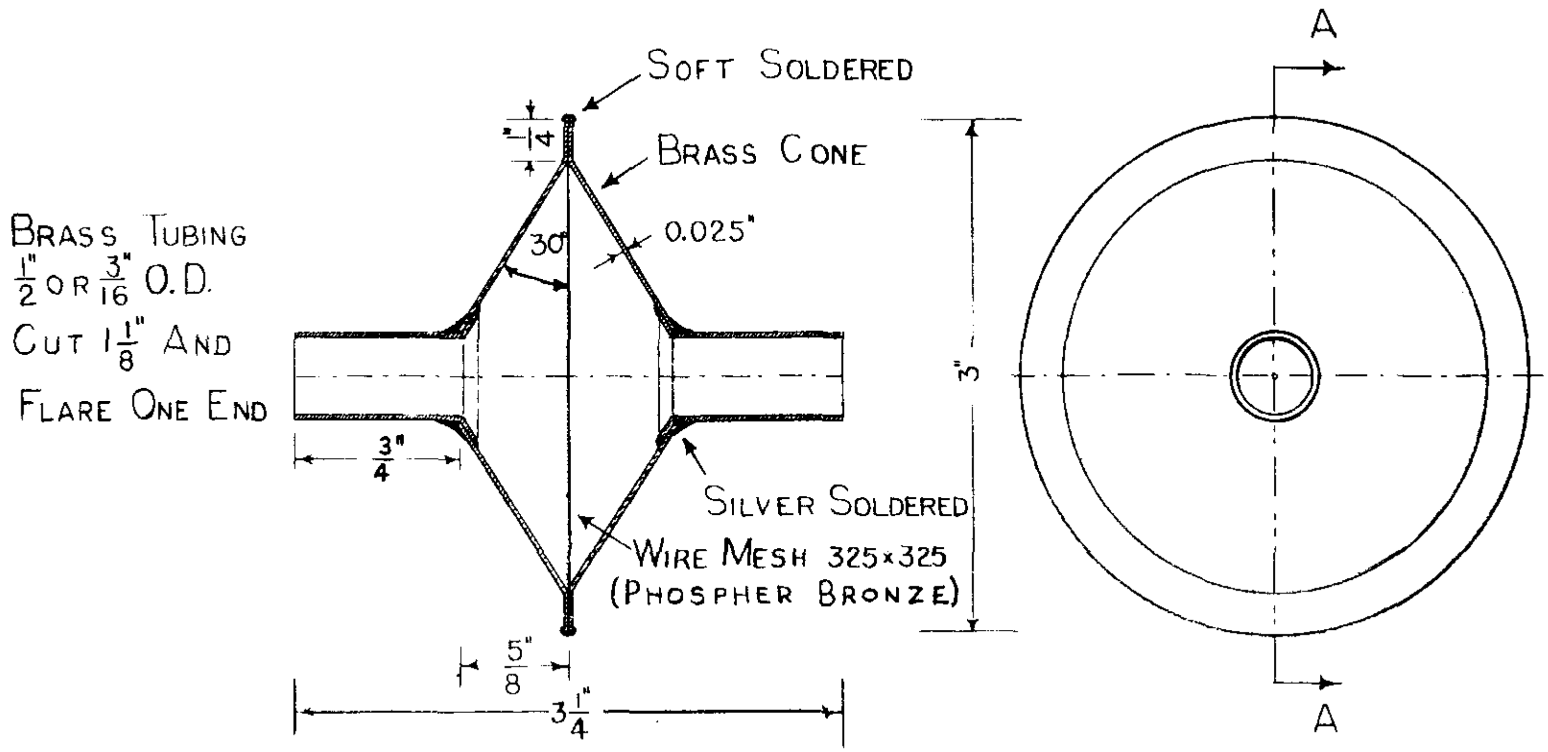


FIG. 8

SCALE 1:1

NOTE
WIRE MESH FROM NEWARK WIRE CLOTH CO., TWILLED WEAVE CODE PYA, OR EQUIVALENT.

NYU BALLOON PROJECT	
TYPE "C" FILTER	
Date: 5-18-48	ED 48-54A

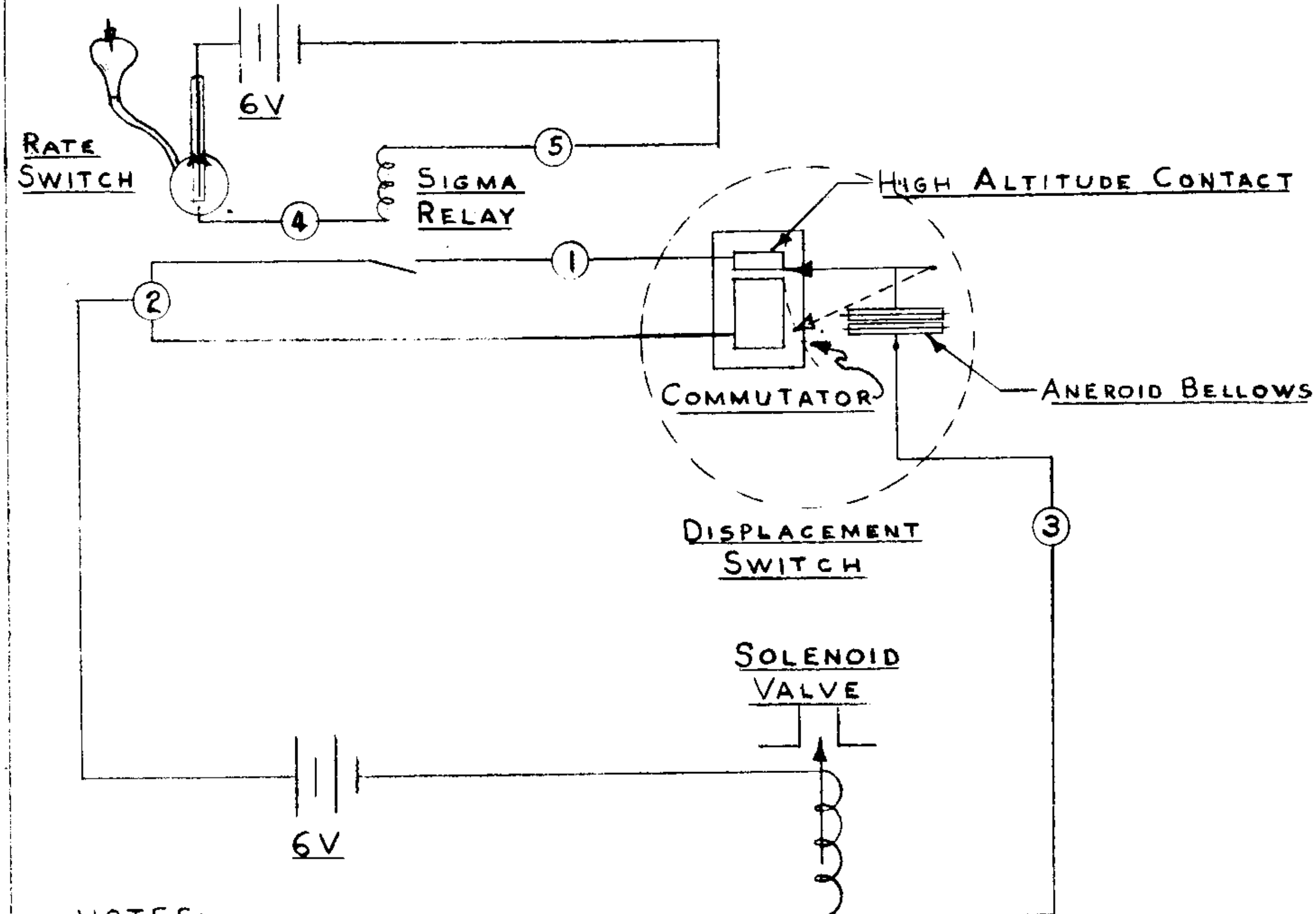
JN

will cause the balloon to descend. Third, as a consequence of the previous limitation, the maximum floating period of a balloon with this control system is 24 hours, achieved when launching is at sunset.

When any or all of the above objections prohibit the use of this simple control system, more complex ballast dropping devices may be used. Figure 9 shows in schematic form the servo or demand type control which has been used to maintain balloons at a constant pressure level, with high ballast efficiency and without harmful sunset effects. Figure 10 is the ballast reservoir assembly which is used with this type control. A more detailed discussion of this servo-control is given in Technical Report Number 2 of the Balloon Project, New York University.

C. Flight Termination Gear

When a balloon loses buoyancy by the loss of lifting gas, it sinks slowly to earth. To prevent the balloon from remaining in airplane traffic lanes for a long period of time, a flight termination device is added to the equipment train. This device, shown in Figure 11, consists of a pressure-actuated switch and rigging to tear a large hole in the balloon when it descends to some predetermined height. A pressure pen is held above its commutator by a short shelf (see Figure 12). After passing an altitude corresponding to the end of the shelf, the pen falls onto the commutator. Upon subsequent descent to 20,000 feet, it closes an electrical circuit. When this circuit is closed, a squib is detonated in an aluminum "cannon" (see Figures 13 and 14) driving a pellet through the main load line. As the line is severed, the weight of the load is suddenly taken by a rip line which extends nearly taut (about 2 feet slack) up the side of the balloon to a point about 10 feet below the balloon crown. At this point, two small holes about 18" apart have been made, and the rip line is passed from the outside into the balloon through the top hole, then down the inside and out the bottom hole. Both holes are securely taped with acetate fiber tape. About 6 inches of slack line is left inside the balloon. When the main line is cut, a large hole is made in the fabric by this rip line as it pulls out of the balloon. After the instruments have fallen about 10 feet and the rip is made, they are caught up by a snub line and the load is again taken to the load ring. The ruptured balloon then acts as a parachute for the load, descending at about 1000 to 1500 feet per minute.



NOTES:

Batt. Pack in Transmitter Box
Sigma Sensitive Type 5F Relay- Coil
Resistance-16000 Ohms
Displacement Switch-ED48-107
Rate Switch-ED 48-115
Solenoid Valve-ED48-110
Use 4FH-6 V Lithium Chloride Batteries (Burgess)
For Details of Displacement Sw. See ED48-126

Fig. 9

Ballast Control Circuit

LHM
11-12-48
ED48-114 B

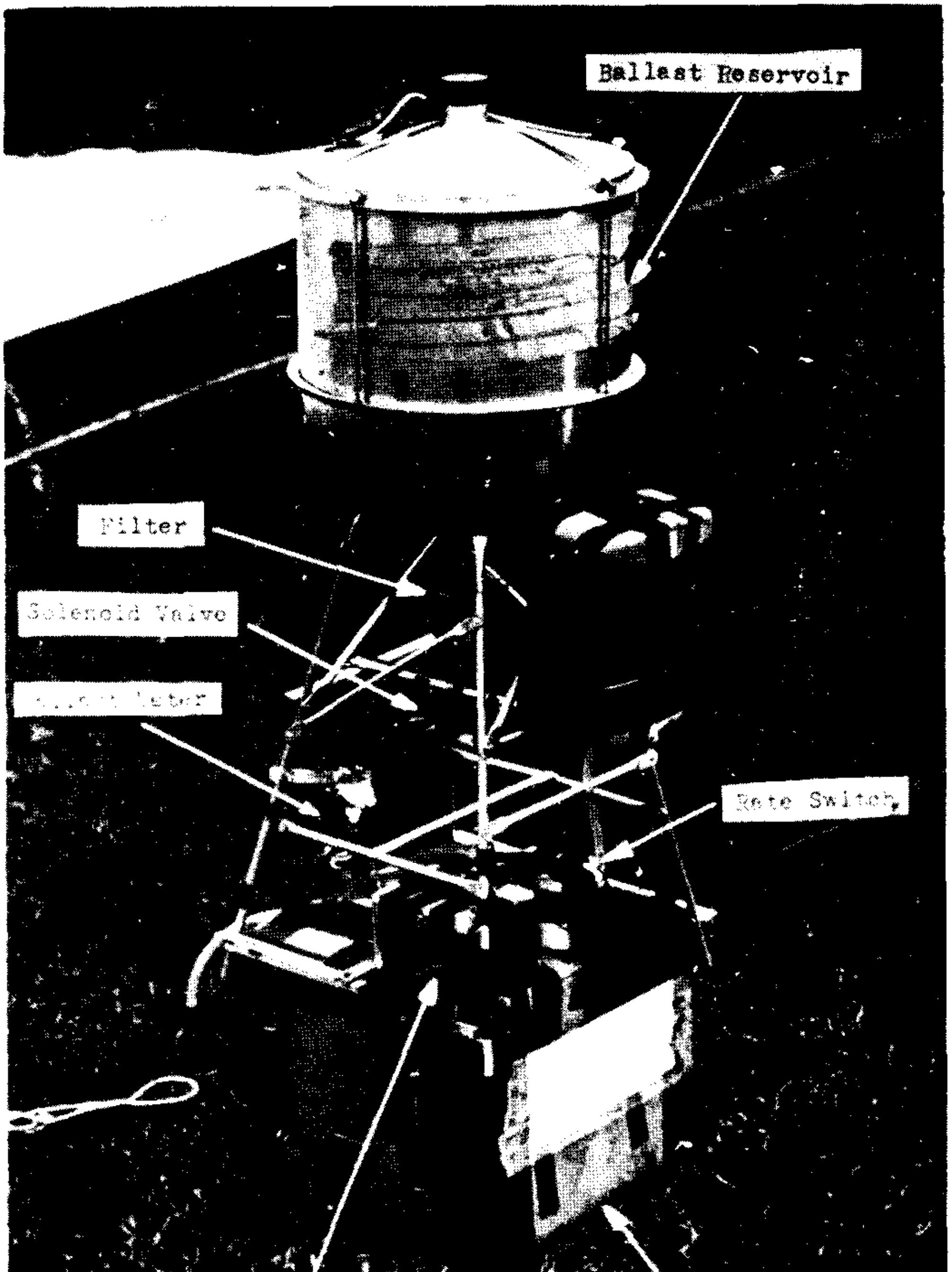


Figure 10

Ballast reservoir assembly
showing component parts

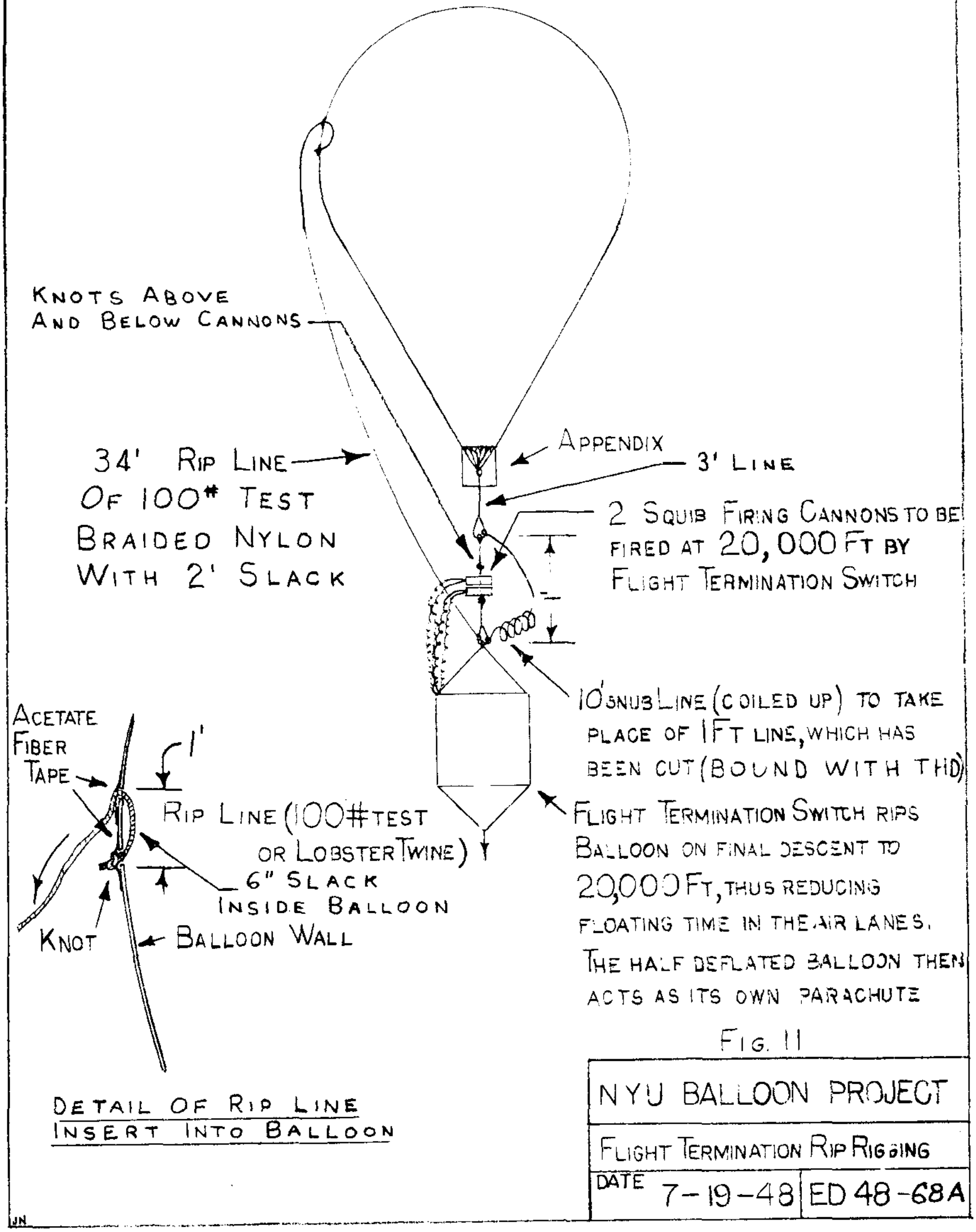
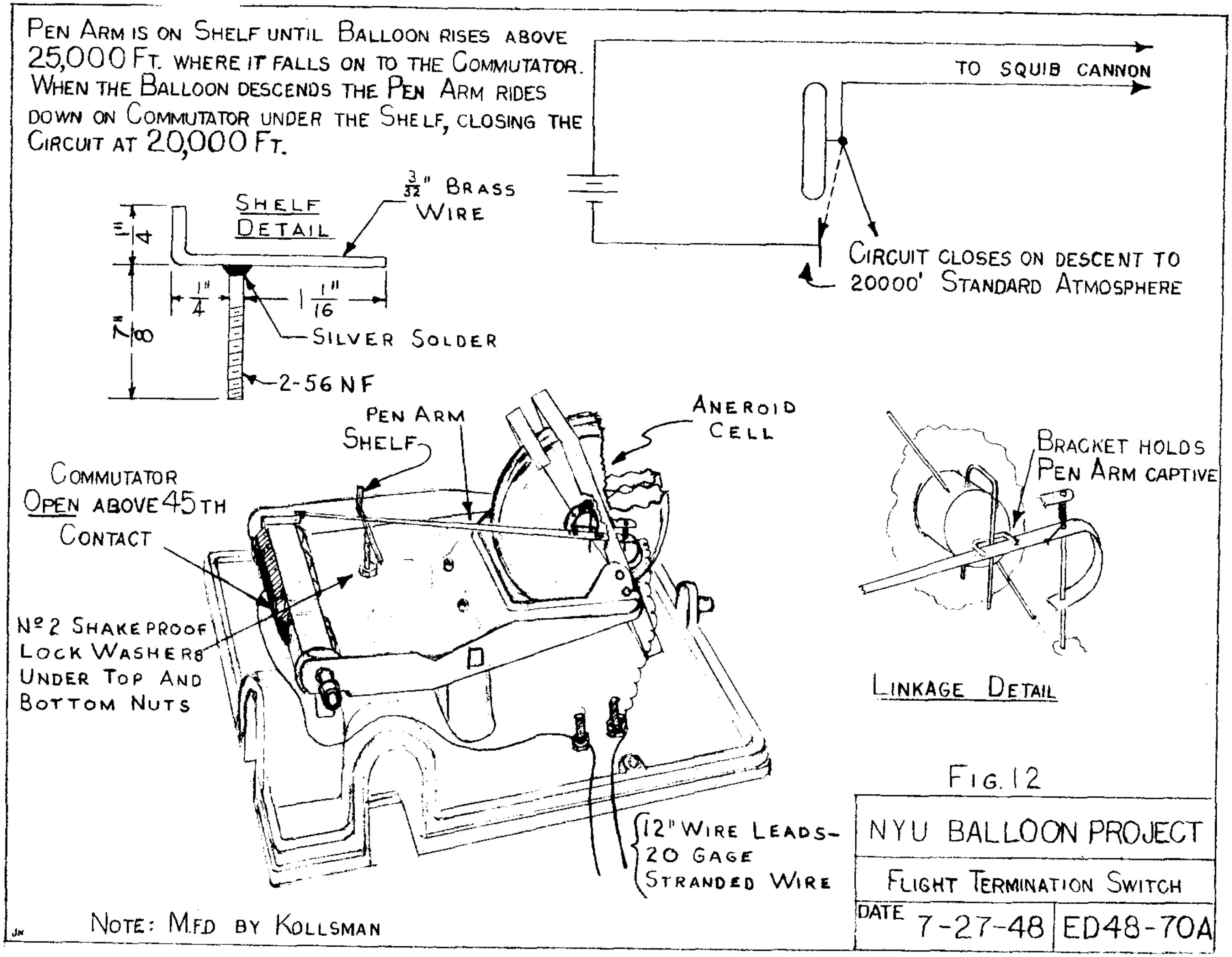


FIG. 11

NYU BALLOON PROJECT	
FLIGHT TERMINATION RIP RIGGING	
DATE 7-19-48	ED 48-68A

JN


PEN ARM IS ON SHELF UNTIL BALLOON RISES ABOVE 25,000 FT. WHERE IT FALLS ON TO THE COMMUTATOR. WHEN THE BALLOON DESCENDS THE PEN ARM RIDES DOWN ON COMMUTATOR UNDER THE SHELF, CLOSING THE CIRCUIT AT 20,000 FT.
TO SQUIB CANNON
CIRCUIT CLOSES ON DESCENT TO 20000' STANDARD ATMOSPHERE
SHELF DETAIL
3/32" BRASS WIRE
1/4"
7/8"
1/4"
1 1/16"
SILVER SOLDER
2-56 NF
PEN ARM
SHELF
ANEROID CELL
COMMUTATOR OPEN ABOVE 45TH CONTACT
Nº2 SHAKEPROOF LOCK WASHERS UNDER TOP AND BOTTOM NUTS
BRACKET HOLDS PEN ARM CAPTIVE
LINKAGE DETAIL
12" WIRE LEADS- 20 GAGE STRANDED WIRE
NOTE: MFD BY KOLLSMAN
FIG. 12
NYU BALLOON PROJECT
FLIGHT TERMINATION SWITCH
DATE 7-27-48
ED48-70A

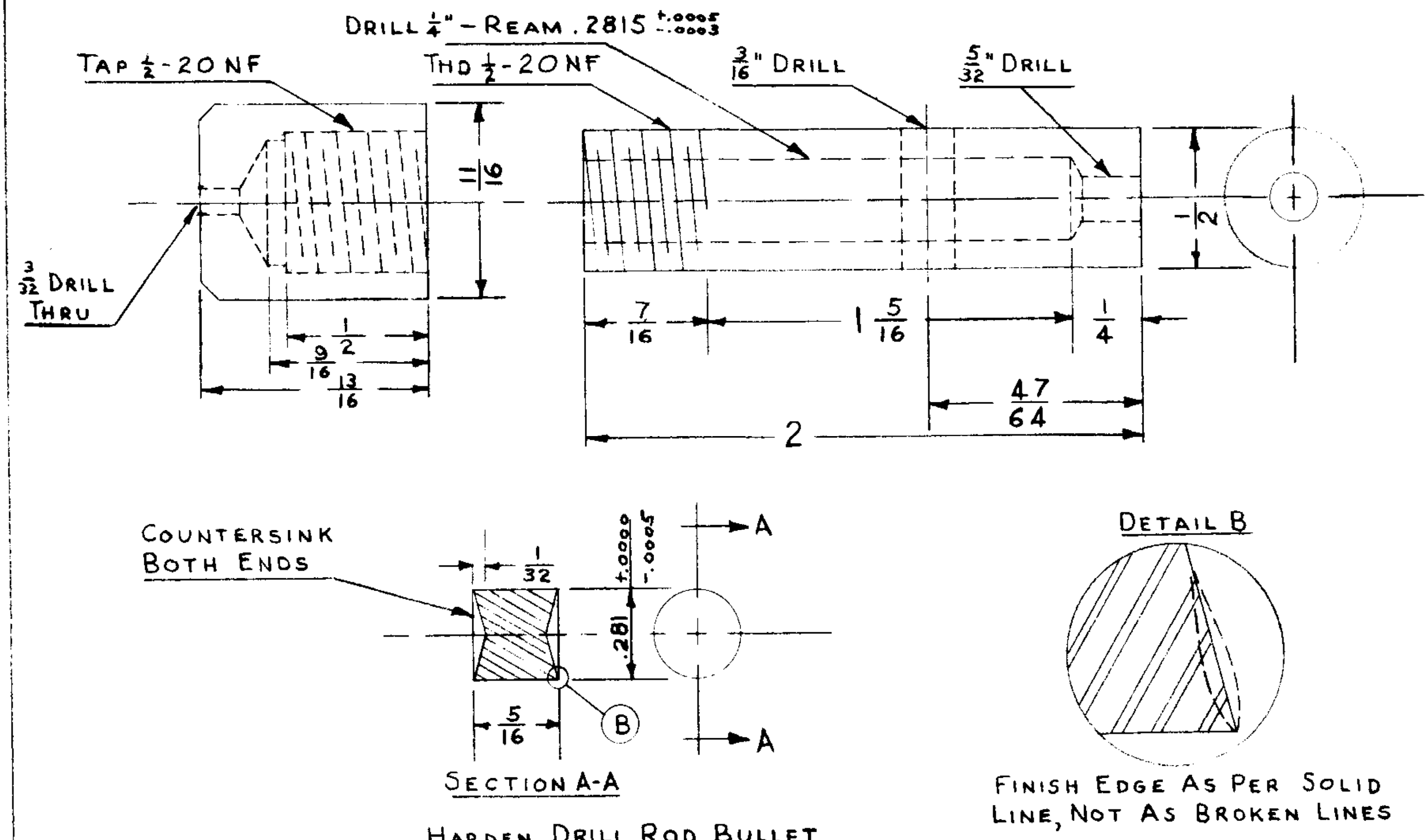


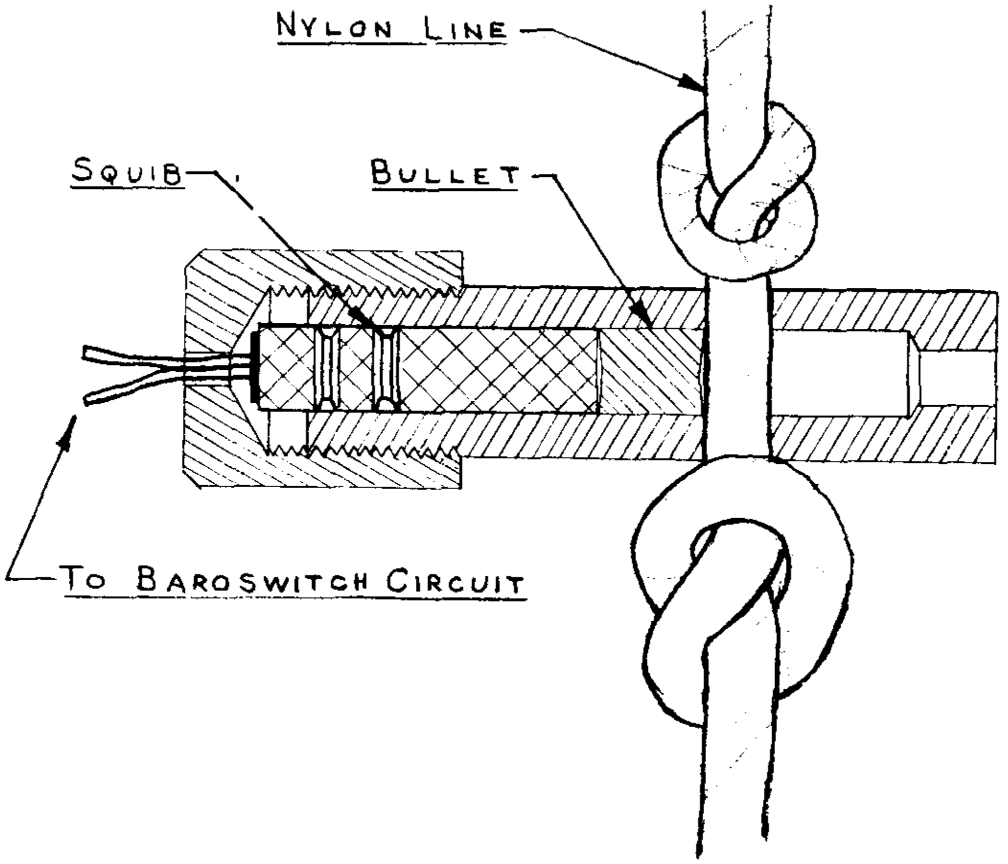
FIG. 13

NOTES:

FOR USE WITH:–
1. DU PONT S-64 SQUIB (3' WIRES)
2. 500# TEST PARACHUTE SHROUD LINE

PART	MATERIAL
CANNON	24 OR 61ST AL
CAP	24 OR 61ST AL
BULLET	DRILL ROD OR
	CAST LEAD

NYU BALLOON PROJECT	
LINE CUTTER CANNON	
LHM 11-15-48	ED48-117A



NOTES

FOR CANNON DETAILS SEE ED 48-117A
USE KNOTS ABOVE AND
BELOW CANNON
SQUIB - DUPONT S-64

FIG. 14

N.Y.U. BALLOON PROJECT

ASSEMBLY OF LINE CUTTER CANNON

DWN BY LHM
DATE 2-1-49

ED49-5A

D. Accessory Flight Equipment

On most flights, three pieces of equipment are added to the train for special purposes. These are: (1) a banner, (2) a drag parachute, and (3) safety weights.

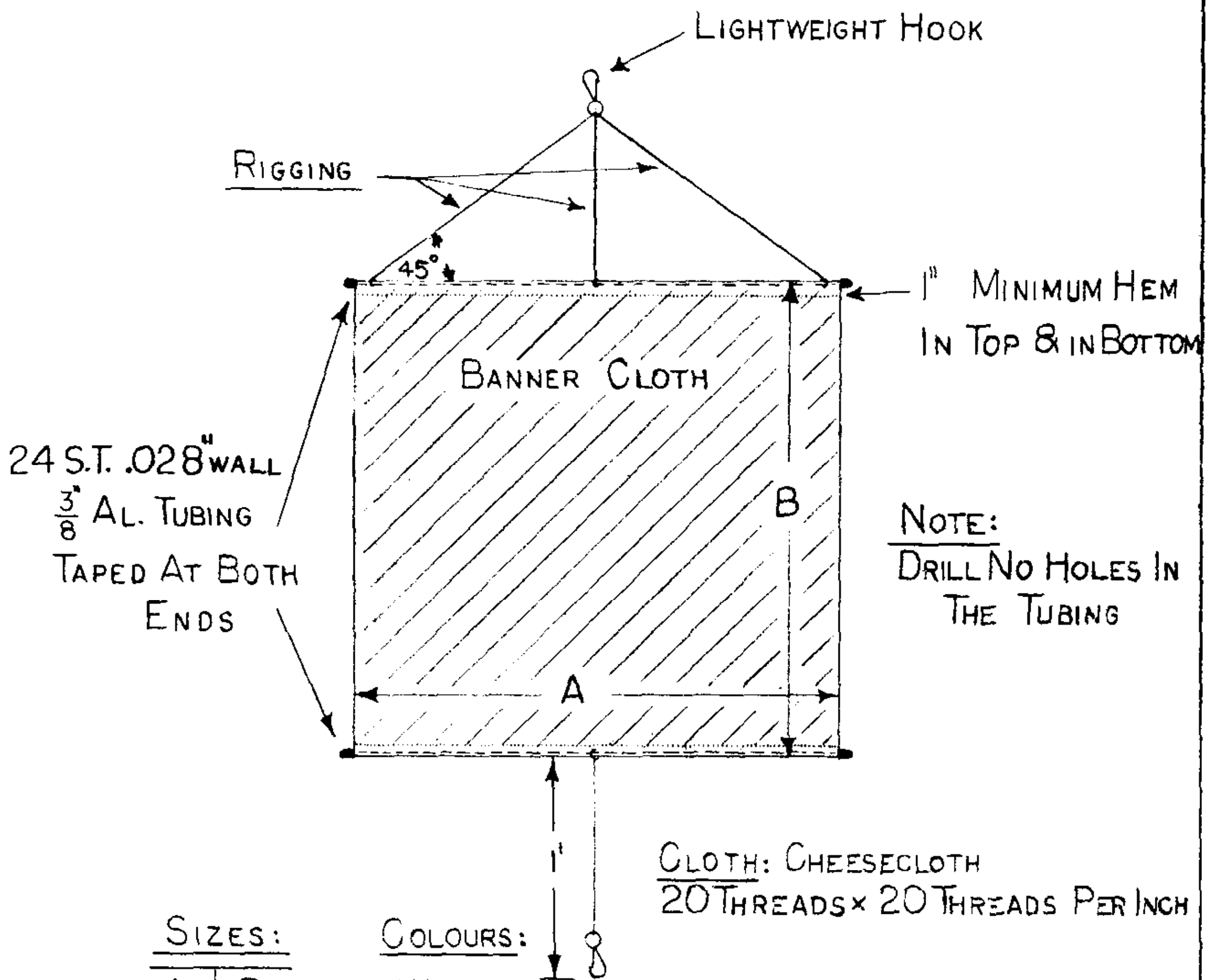
The banner is a red or yellow cheesecloth rectangle, 3 x 6 or 6 x 12 feet, with aluminum spreaders at top and bottom. Shown in Figure 15, the banner is tied taut to the load line, and serves to reduce sidewise swaying as the balloon rises. Due to the bright color, it is useful in locating the balloon after being grounded and acts as a warning to air craft during descent and ascent. If thodolite stadia determinations are being made, the banner can be used as one of the check points on the train.

The drag parachute is inserted into the train above the banner in inverted position and serves to retard the ascending balloon somewhat, thus reducing the probability of bursting due to excessive rates of rise.

To correct a too slow rate of rise, (which may result from under inflation due to gage errors, freezing of valves, or excessive adiabatic cooling of the gas during inflation) two small bags of sand or shot are added to the bottom of the restraining line. If it appears that the balloon is not rising with the desired velocity as it picks up the equipment, one or both of these safety weights are cut free. The weight of each bag is equal to the desired free lift, so that if the computed free lift is not available, this lift may be supplied. Prior to the adoption of this practice, it was necessary to sacrifice equipment or the balloon in such cases.

E. Tracking and Recording Instruments

Depending upon the nature of the flight, the weather conditions, and the equipment available, gear may be added to the flight train to aid in horizontal position determination and altitude measurement. The discussion of suitable equipment for such work is given in Section VII. In general, the equipment added may be either radio transmitters or gear of other assorted types. Each unit is rigged separately, with hooks at each end of the line segment. Prior to the inflation of the balloon a thorough check of all such equipment, especially radio gear, is made. It is necessary to have spare equipment tested, calibrated, and assembled for last minute replacement if failure is detected at this time.



SIZES:

A	B
3'	3'
6'	6'
6'	12'
3'	6'

COLOURS:

WHITE
YELLOW
RED

FIG. 15

NYU BALLOON PROJECT	
BANNER	
Date: 5-19-48	ED 48-56

Position of recording and radio instruments in the flight train is in some cases dictated by the size and shape of antennae or other special part. In general this type of gear is not placed below the altitude control equipment because of possible damage which might result from ballast being dropped upon them. Typical trains are shown in Figures 16, 17, and 18.

F. Flight Tools and Equipment

A list of tools and equipment and facilities which should be provided for any launching site is given in Appendix II.

IV. PRE-FLIGHT COMPUTATIONS

A. Lifting Gas and Rate of Rise

When the equipment for a flight is in readiness and the inflation procedure is to be begun, the total weight to be lifted must be determined. A weight sheet (shown in Appendix I) is filled in, with the final weight of each piece of gear with its rigging. In this work the weights of the equipment are measured in grams and kilograms for ease of computation. The gross load reported should be accurate to the nearest 200 grams. The amount of lifting gas to be used must be carefully figured to prevent incorrect inflation which might result either in the balloon failing to rise, or perhaps rising too fast and rupturing at its ceiling. After the total weight to be lifted is found, a percentage of this total is added to provide for lifting the load at some specified rate. With a given excess of buoyancy, a balloon will lift its load at an almost constant predictable speed. (The rate of rise will increase by about 25% at higher altitudes, due to the changes in balloon shape and decrease of air density.) Graph 1 of Appendix II shows the relationship between the free lift and the rate of rise, with free lift expressed as a percentage of the total or gross load (which includes the weight of the balloon itself). For example, if a gross load of 10.0 kilograms is to be lifted at a desired ascent rate of 600 feet per minute, 9.2% of the gross load should be added, giving a gross lift of 10.0 + .920 = 10.920 kilograms. (The rate of rise should not exceed 700 feet per minute if a standard appendix is used.)

It should be noted that this graph, derived from equations for spherical balloons, applies also to the tear-drop cells of General Mills, Inc., without regard for the balloon diamter.

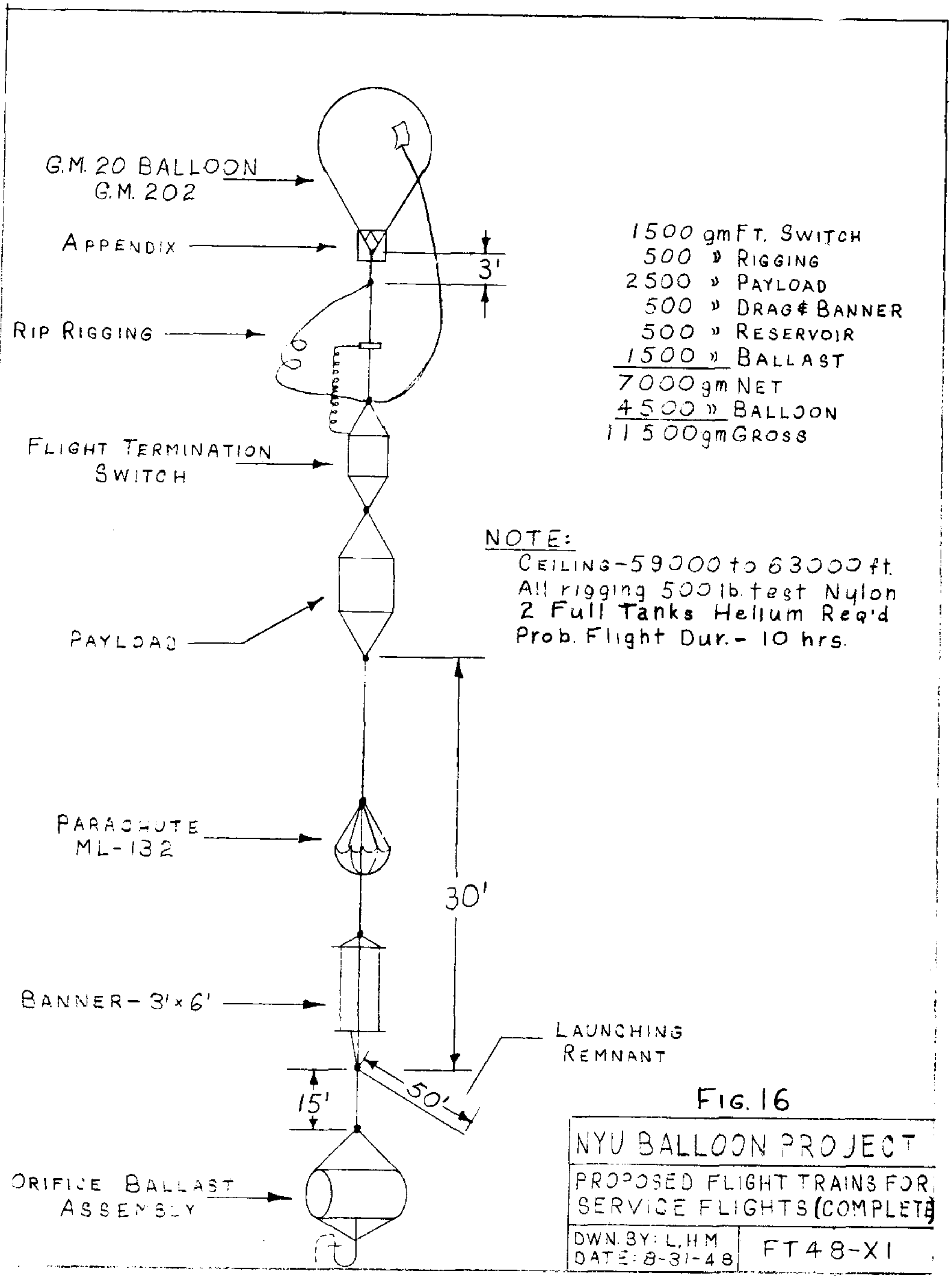
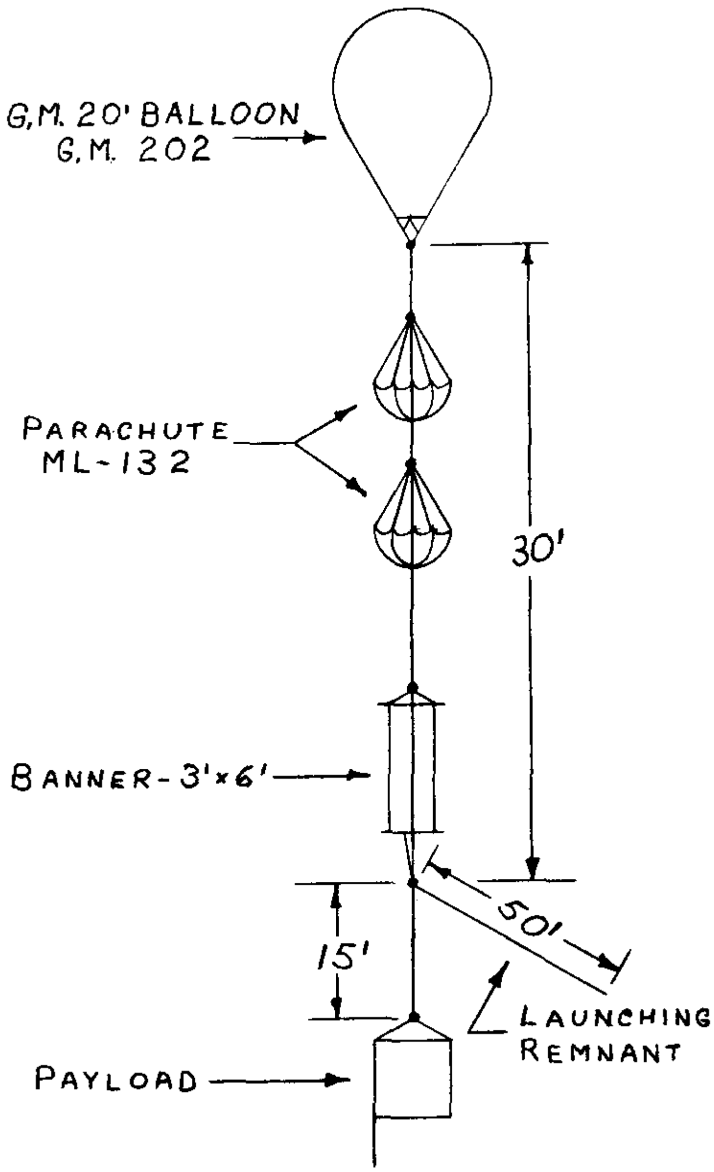

G.M. 20 BALLOON
G.M. 202
APPENDIX
3'
RIP RIGGING
FLIGHT TERMINATION SWITCH
PAYLOAD
PARACHUTE ML-132
30'
BANNER – 3'×6'
LAUNCHING REMNANT
50'
15'
ORIFICE BALLAST ASSEMBLY
1500 gm FT. SWITCH
500 " RIGGING
2500 " PAYLOAD
500 " DRAG & BANNER
500 " RESERVOIR
1500 " BALLAST
7000 gm NET
4500 " BALLOON
11500 gm GROSS
NOTE:
CEILING – 59000 to 63000 ft.
All rigging 500 lb. test Nylon
2 Full Tanks Helium Req'd
Prob. Flight Dur. – 10 hrs.
NYU BALLOON PROJECT
PROPOSED FLIGHT TRAINS FOR SERVICE FLIGHTS (COMPLETE)
DWN. BY: L.H.M
DATE: 8-31-48
FT48-X1

FIG. 16



500	gm	DRAG CHUTES
300	"	BANNER
2000	"	PAYLOAD
4500	"	BALLOON
7300	"	GROSS LOAD

NOTE:

Use low rates of rise (500 ft per min) to prevent balloon failure during ascent.

All rigging 500 lb. test Nylon.

Max. Ceiling with this load: 67000 to 70000 ft.

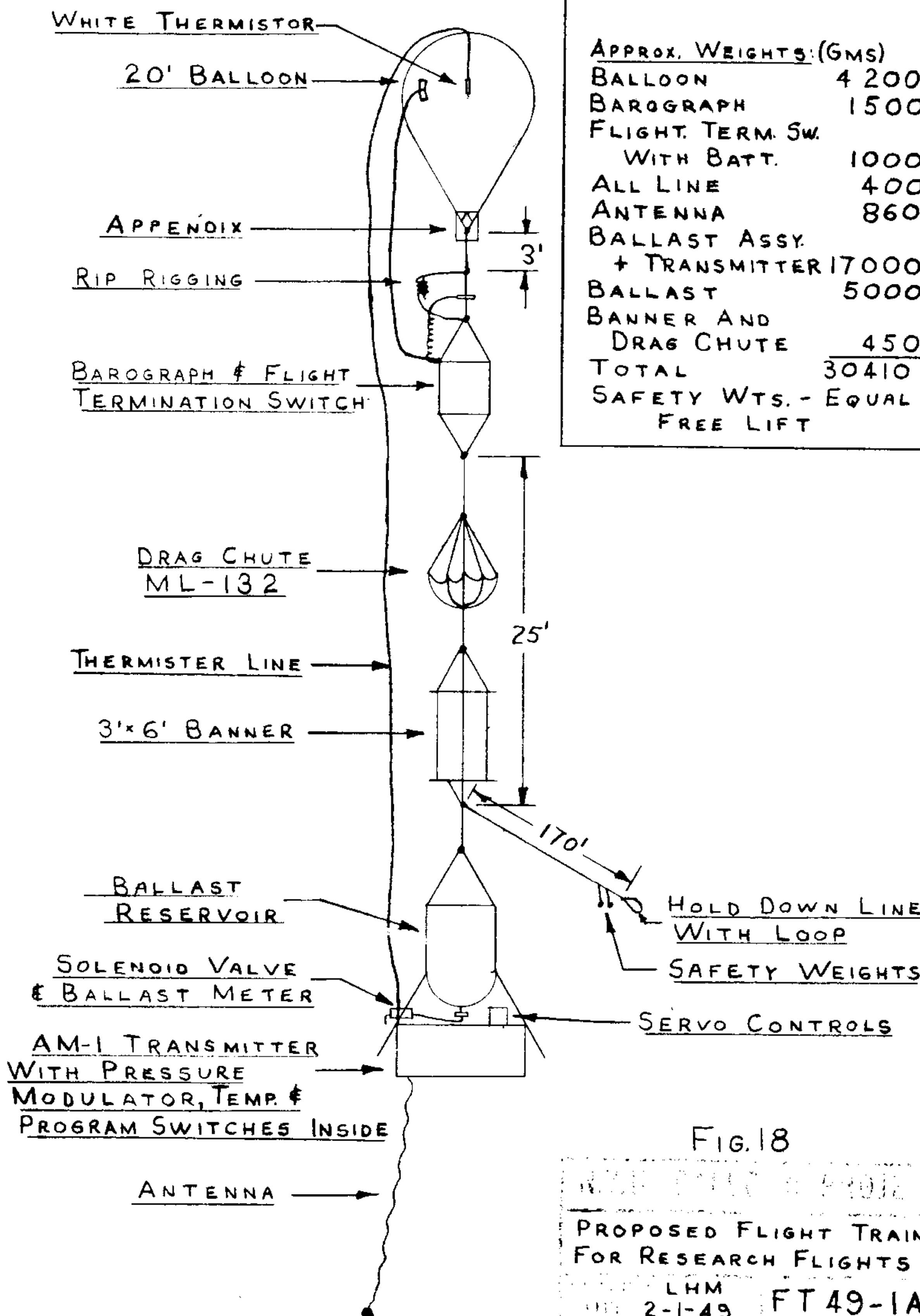
Probable Ceiling: 45000 ft. since no appendix is used.

Prob. Flight Duration- 3 hrs.

1 1/4 FULL TANKS HELIUM REQ'D.

FIG. 17

NYU BALLOON PROJECT	
PROPOSED FLIGHT TRAINS FOR SERVICE FLIGHTS (SIMPLE GEAR)	
DWN. BY: L.H.M. DATE: 8-30-48	FT48-X2



Approx. Weights: (Gms)	
Balloon	4 200
Barograph	1500
Flight Term. Sw. With Batt.	1000
All Line	400
Antenna	860
Ballast Assy. + Transmitter	17000
Ballast	5000
Banner And Drag Chute	450
Total	30410

Safety Wts. – Equal To Free Lift

Fig. 18

Proposed Flight Trains For Research Flights

LHM 2-1-49 FT 49-1A

When the total quantity of gas needed has been computed, the lift requirement may be expressed in terms of the pressure of a number of cylinders of gas. It is not possible to assume that each tank of gas will give the same amount of lift, nor is it possible to use a gage which has not been experimentally calibrated to relate lift to pressure. For calibration of a gage it is sufficient to valve gas from an observed equilibrium temperature and pressure in a cylinder into a rubber balloon and then measure the total lifting capacity of the gas from the tank. Check points should be made with tanks under varying amounts of pressure. Figure 19 shows a sample gage calibration worked up for varying temperatures assuming the simple gas law

$$Lift_2 = \frac{P_2}{P_1} \times \frac{T_1}{T_2} Lift_1$$

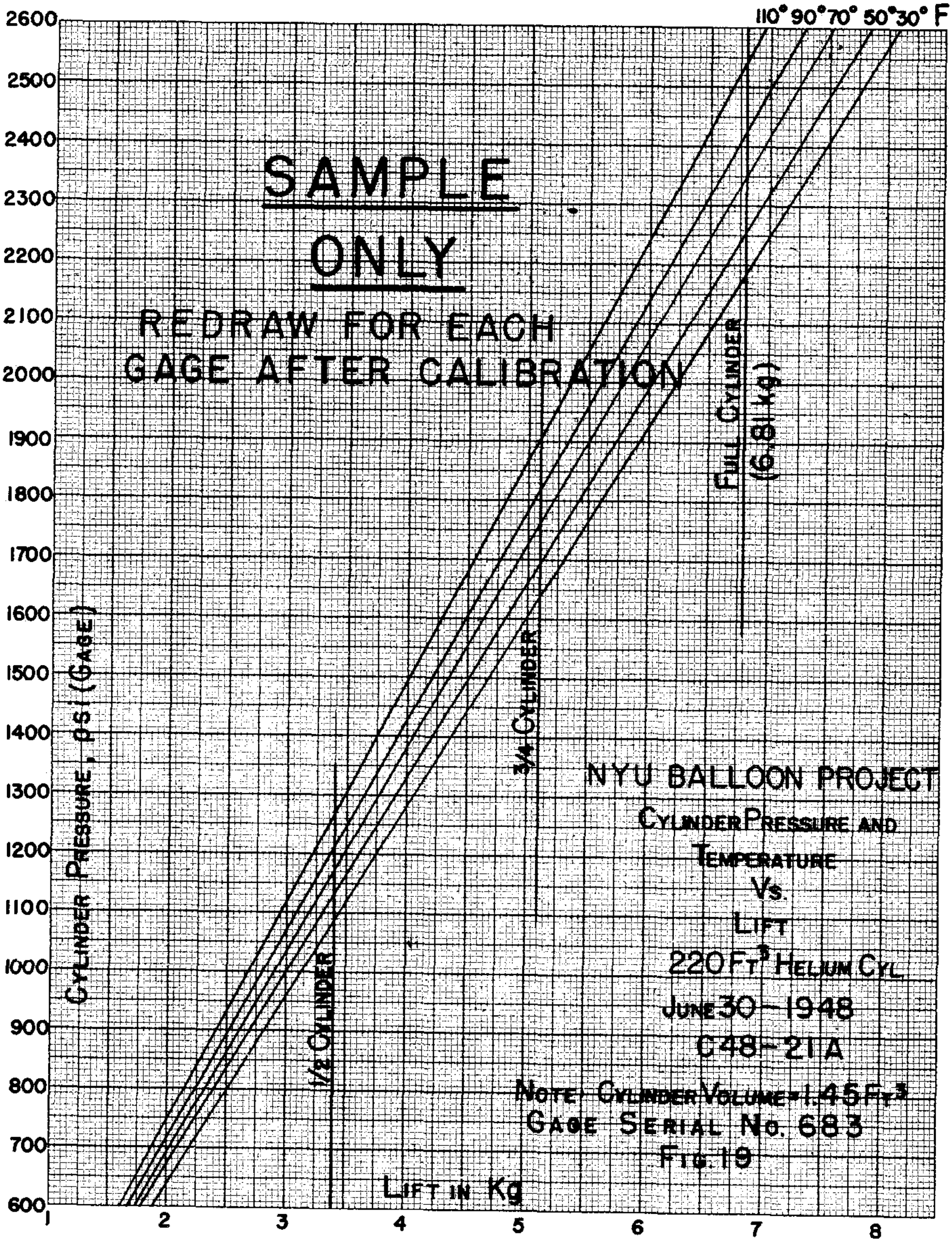
This law applies to within ±1%. Note: Do not use Graph 6 without checking calibration of gage to be used. Ordinarily a whole number of full tanks of gas will not exactly supply the desired lift, which should be figured with not more than one-tenth full tank tolerance in excess (permit no under inflation). It is thus necessary to prepare partially full tanks and by combining full and partially full cylinders get the required total. It is necessary to allow the cylinders to attain equilibrium temperature after valving them before taking final pressure readings.

B. Length of Balloon Bubble

The volume of gas required for a given balloon may be expressed as the length of an uninflated bubble at the crown of the balloon. Graph 2 of Appendix II gives the relationship between bubble length and resultant inflated volume, using gross lift as an expression of volume. It will be noted that when the elevation of the launching site is markedly different from sea level, a shift in this curve is needed to accomodate varying densities of the atmosphere. The inflation of this bubble, which is pinched off by launching equipment or shot bags, will serve as a good check of the final amount of gas in the balloon, thus warning if the balloon is underinflated.

C. Expected Altitude

To predict the altitude to which a balloon will rise it is necessary to know the volume of the balloon, the total


110° 90° 70° 50° 30° F
SAMPLE
ONLY
REDRAW FOR EACH
GAGE AFTER CALIBRATION
FULL CYLINDER
(6.81 kg)
3/4 CYLINDER
1/2 CYLINDER
CYLINDER PRESSURE, psi (GAGE)
LIFT IN Kg
NYU BALLOON PROJECT
CYLINDER PRESSURE AND
TEMPERATURE
VS.
LIFT
220 FT³ HELIUM CYL.
JUNE 30 - 1948
C48-21A
NOTE: CYLINDER VOLUME = 1.45 FT³
GAGE SERIAL NO. 683
2600
2500
2400
2300
2200
2100
2000
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
1
2
3
4
5
6
7
8
FIG. 19

weight of equipment and balloon, the distribution of density in the atmosphere and the buoyancy of the lifting gas. Assuming that the lifting gas is helium, Graph 3 in Appendix II summarizes the relationship between gross load and floating level for balloons of several diameters. To use this graph to find the floating level of a balloon of given size and load, enter with the required buoyancy (equal to the gross load). Go vertically to the diagonal line corresponding to the balloon size and then horizontally to the extreme left-hand edge and read the altitude. The volume of the balloon is related to density by the use of the molar volume in this chart. Assuming observed pressure and temperature distributions over selected stations and the N. A. C. A. standard atmosphere, the molar volume is given as well as the altitudes. Table 1 of Appendix II gives the N. A. C. A. Standard Atmosphere relating pressure with altitude, and Table 2 gives the variation of temperature with altitude. For local conditions more exact measurements may be made using the temperature and pressure distribution indicated by a sounding rather than the standard. To do this, it is necessary to compute the molar volume from this relationship

$$\text{molar volume}_z = 359 \text{ ft.}^3 \times \frac{T_z}{273^\circ C} \times \frac{1013.3 \text{ mb}}{P_z}$$

Example: Find the molar volume at 30,000 feet MSL where the reported temperature is -30°C, and the reported pressure is 300 mb.

$$\text{molar volume}_{30,000} = 359 \text{ ft.}^3 \times \frac{(273-30)^\circ C}{273^\circ C} \times \frac{1013 \text{ mb.}}{300 \text{ mb.}} = 1080 \text{ ft.}^3$$

This is the volume of a pound mol of any gas at those conditions.

By plotting several points of this curve of molar volume versus altitude, it is possible to locate very exactly the altitude which corresponds to the molar volume to which the balloon will go (found from Graph 3 or as follows). This density or molar volume to which a balloon will rise is given by the following formula:

$$\text{Molar volume} = \frac{\text{Balloon volume}}{\text{Gross load}} \text{ Gas Lift/mol}$$

Gas lift/mol = 11.1 kg/mol (using Helium)

D. Ballast Requirements

For a 20-foot General Mills balloon, a flow of ballast of at least 200 grams per hour is needed to keep the balloon aloft. Flow of the compass fluid used varies (through a sharp-edged orifice) with the head, or vertical distance between the free surface of the liquid and the orifice. It is not affected by the temperature or pressure, so long as the reservoir is properly vented.

Flow also varies with the size and shape of the orifice. Using round spinnerette orifices, the flow of various heads has been computed and is shown in Table 3, Appendix II. From a knowledge of the minimum head to be expected (depending on the construction of the ballast reservoir and its connection to the orifice), the desired rate of flow can be obtained by proper selection of orifice size. While 200 grams per hour has been used successfully for the usual floating altitudes of the General Mills 20-foot cells, this figure should be considered as an absolute minimum. A short period check of the flow rate through each ballast assembly prior to flight is recommended.

E. Altitude Sensitivity

The altitude gained by a balloon when its load is reduced by one kilogram is called its altitude sensitivity. This amount is affected by the density of the atmosphere at the floating level; for 20-foot balloons between 40,000 and 53,000 feet, it is roughly 1000 feet per kilogram of weight lost. This weight is normally lost by ballast dropping. The altitude sensitivity and the ballast drop control the rate of rise of the ceiling. Graph 4, Appendix II gives more exact values for this figure at various altitudes.

F. Forms and Records

For the purpose of making standard pre-flight computations, a series of computation sheets have been drawn up. These are shown in Appendix I. Reward tags attached to components of the flight train have encouraged the finders to protect the equipment and report its location for recovery. The tags, questionnaires, and the warning notices which are used on appropriate gear where squibs or acid are used are shown in Figures 20 and 21.

V. BALLOON INFLATION

A. Preparation of Balloon

From the moment the protective packing of the balloon is removed, great care must be exercised to prevent tears

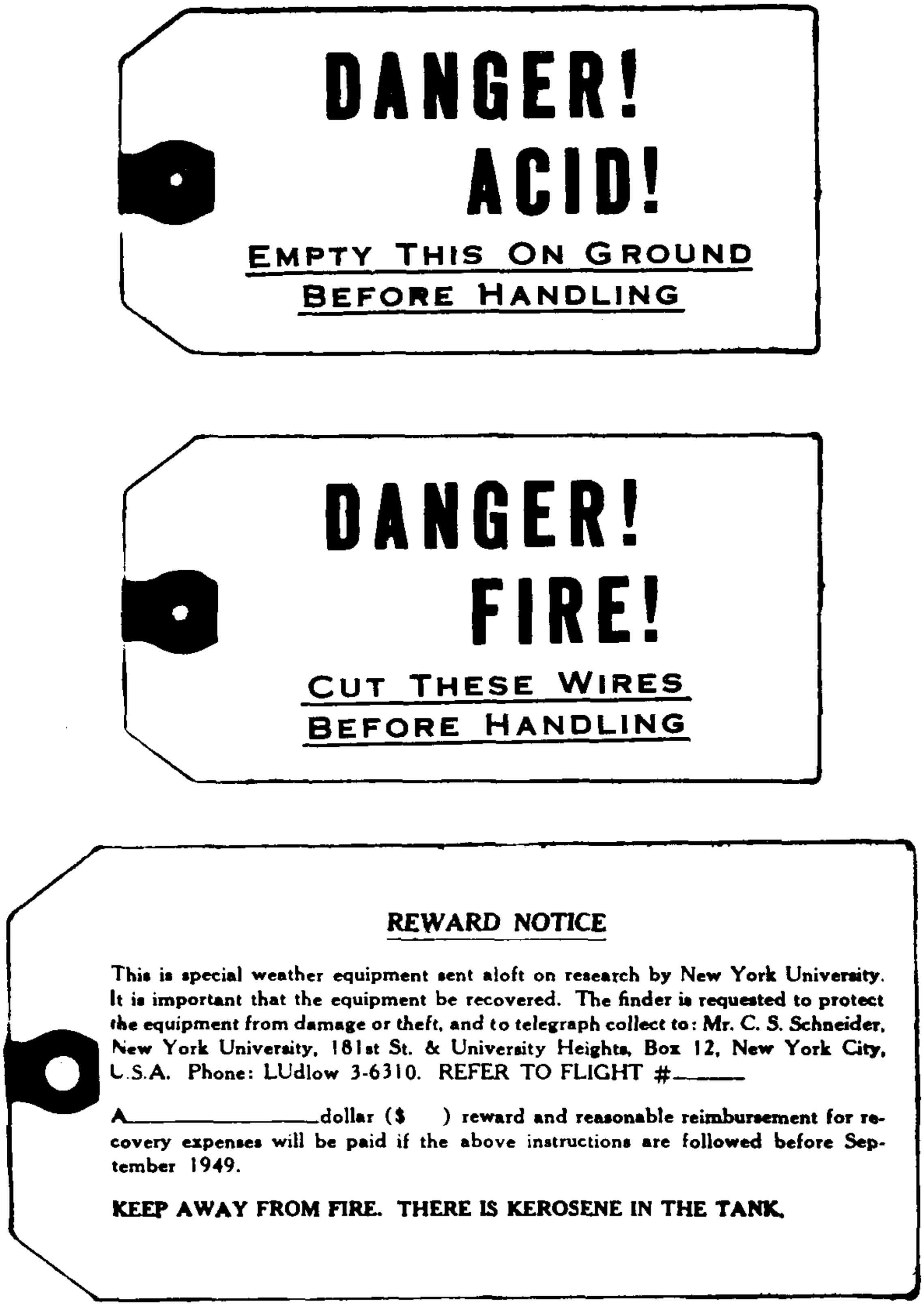


Figure 20
Sample warning and reward tags

QUESTIONNAIRE

Please answer this and send to us so that we may pay you the reward.

1. On what date and at what hour was the balloon discovered?
2. Where was it discovered? (Approximate distance and direction from nearest town on map?)
3. Was it observed descending? If so, at what time?
4. Did it float down slowly or fall rapidly?
5. How much kerosene was there in the tank?

Remuneracion

La materia ha volado con este globo desde la Nueva York University para hacer investigaciones meteorologicas. Se desea que esta material se vuelva para estudiarle nuevament.

Con este motivo, se dara una remuneracion de ________ dolares norteamericanos y una suma proportional para devolver todos los apartos en buen estado. Para recibir instrucciones de embarque, comuniquense con la persona siguiente por telegrafo, gastos pagados por el recipiente, refirriendo al numero del globo ________.

CUIDADO!
PELIGRO DE FLAMA, HAY KEROSEN EN EL TANQUE.

C. S. Schneider
Research Division
New York University
University Heights
Bronx 53, New York

Figure 21
Sample Spanish reward notice and English questionnaire.

and pin holes from being made in the fabric. For example, the film is so easily injured that it is not safe to lay a folded-up balloon on a bare table-top or other hard surface on which sand or splinters might be found. For this reason a clean ground cloth of canvas should always be used for the lay-out of the balloon. Once the balloon has been laid out on the ground cloth, it is made ready for inflation and the rip line of the flight-termination gear is inserted into the cell (see Section III, C).

B. Use of Shot Bags and Releasing Device

While the balloon is being inflated it is necessary to hold it in position. Under conditions of calm wind, this may be accomplished by simple fastening heavy weights to the loading ring and allowing the entire balloon envelope to rise freely above its anchor.

Since only 10 to 20% of the balloon is full at the surface when the inflation is complete, it is possible to restrict the volume filled and so cut down the area exposed to the wind on days which are not calm. The volume required can be expressed as the length of the bubble collected at the head or top of the balloon. Having determined the desired length (see Section IV, B), the remainder of the balloon may be held down on the ground cloth by weighted bags wrapped in protective sheets of polyethylene (see Figures 22 and 23). Elliptical shot bags, weighing 100 pounds, are used to hold the base of the bubble to be inflated. Twenty-pound sand bags are used to keep the appendix closed to prevent filling of the balloon with air and to restrict the uninflated folds of the balloon. A more elaborate system of holding the gas in the upper section of the bubble makes use of the General Mills releasing device shown in Figures 24 and 25. Mounted on wheels, this mechanism is rolled into position with the head of the balloon lying across the platform. The protective roller arms lock into position holding the bubble until launching. This device is used with large loads when shot bags might roll or slide off the balloon. As the arms open outward as well as upward when the locking pins are removed, it is necessary to position the platform with the arms opening away from the bubble.

C. Inflation Techniques

When the balloon is manufactured, a polyethylene inflation tube about 4" in diameter is inserted. This tube extends from a few feet outside the appendix to near the top of

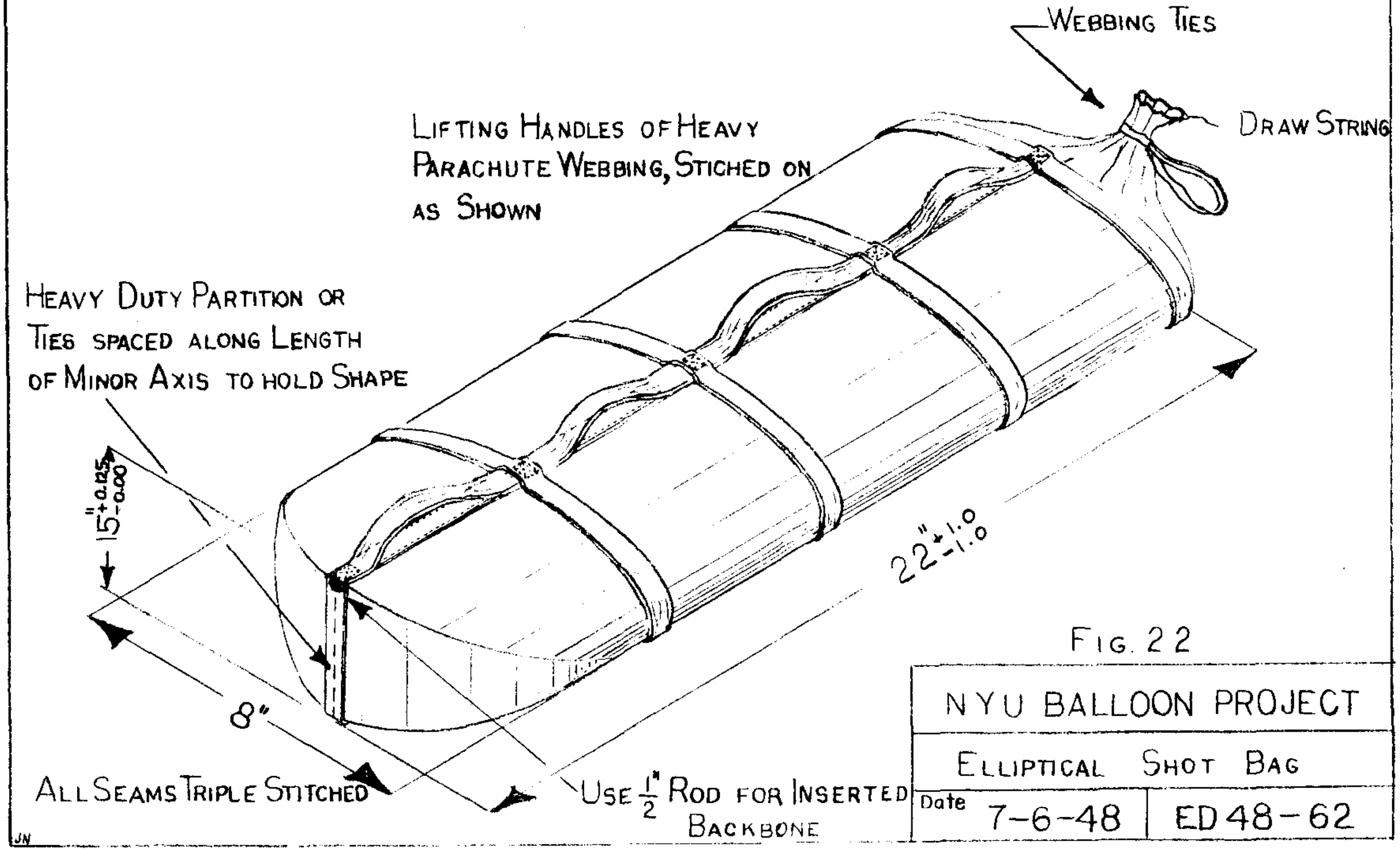
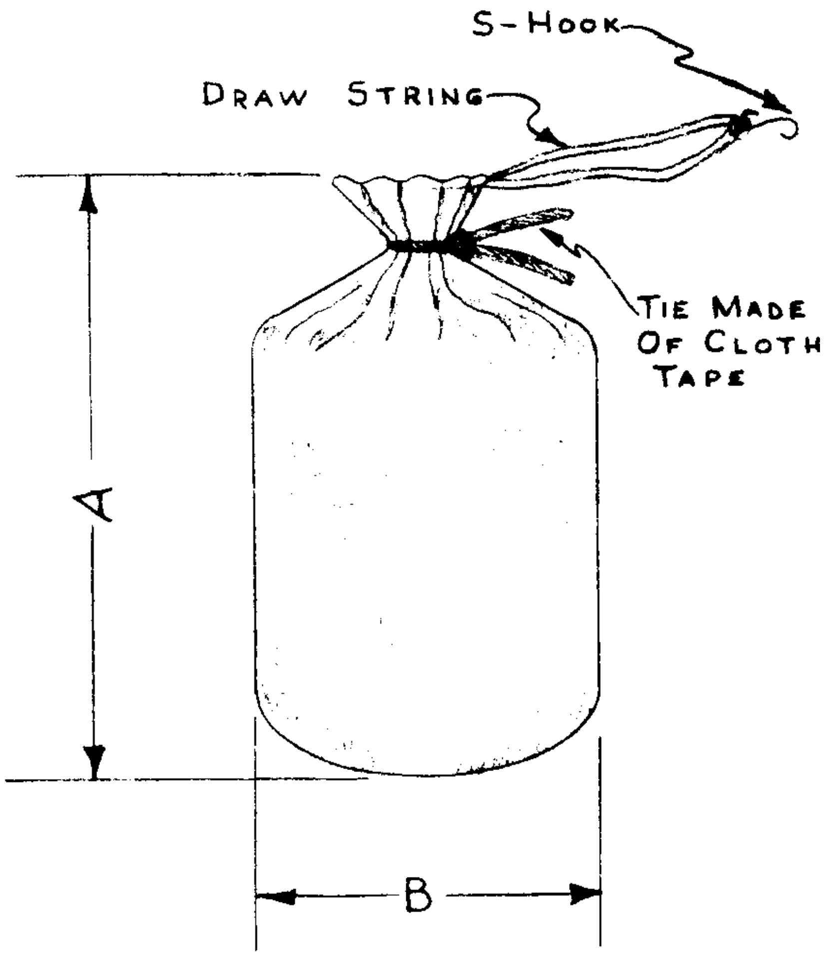


FIG. 22

NYU BALLOON PROJECT

ELLIPTICAL SHOT BAG

Date 7-6-48	ED 48-62



BAG SPECIFICATIONS			
Type	A	B	Bottom
40# Sand	12"	10"	Double
40# Shot	7"	6"	Double
Safety Wt.	5"	3"	Single

Material - Heavy Canvas Duck

Fig. 23

[illegible] BALLOON PROJECT	
Sand And Shot Bag Specifications	
[illegible] LHM [illegible] 11-23-48	ED48-122A

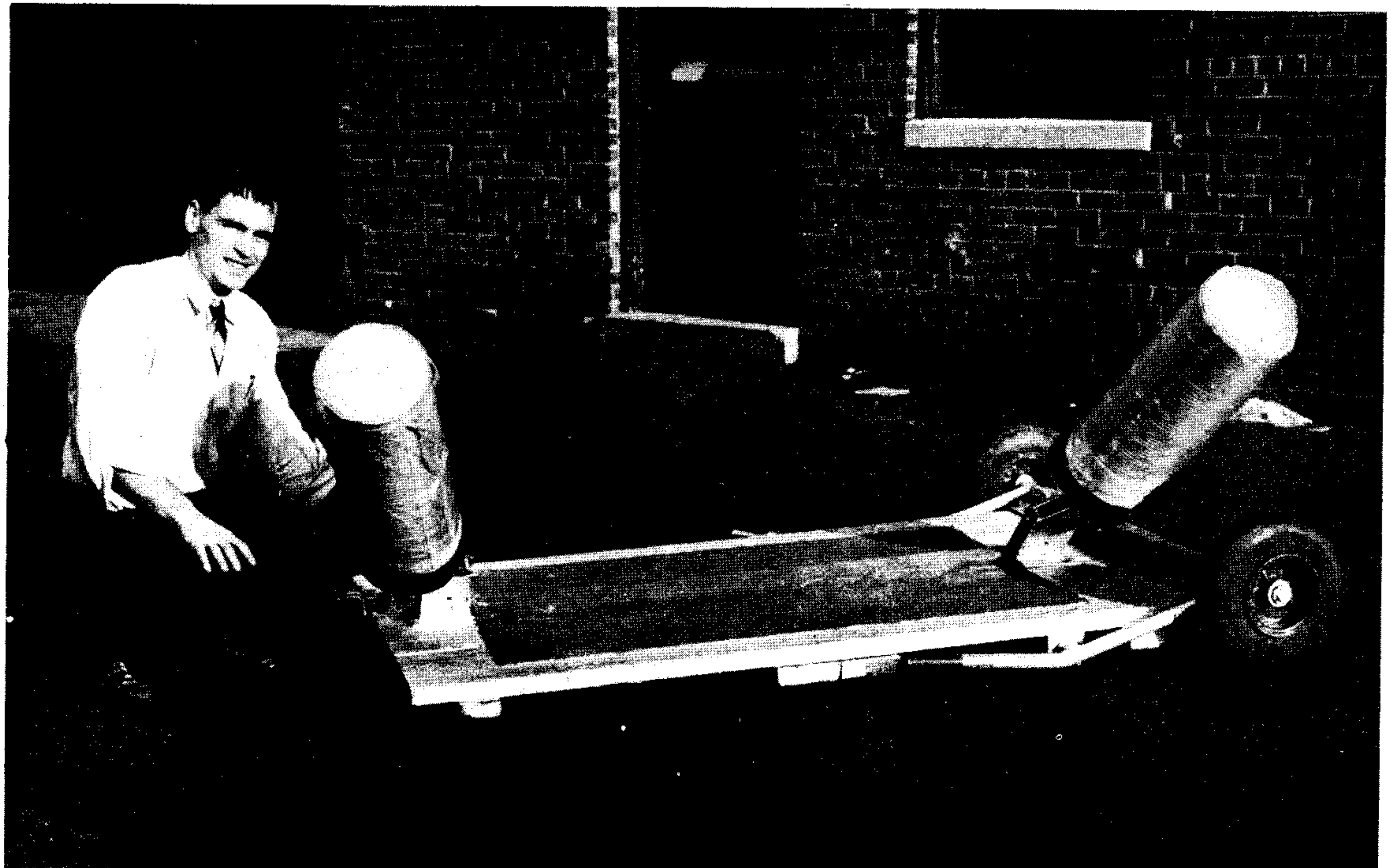


Figure 24
General Mills launching platform for large balloons.

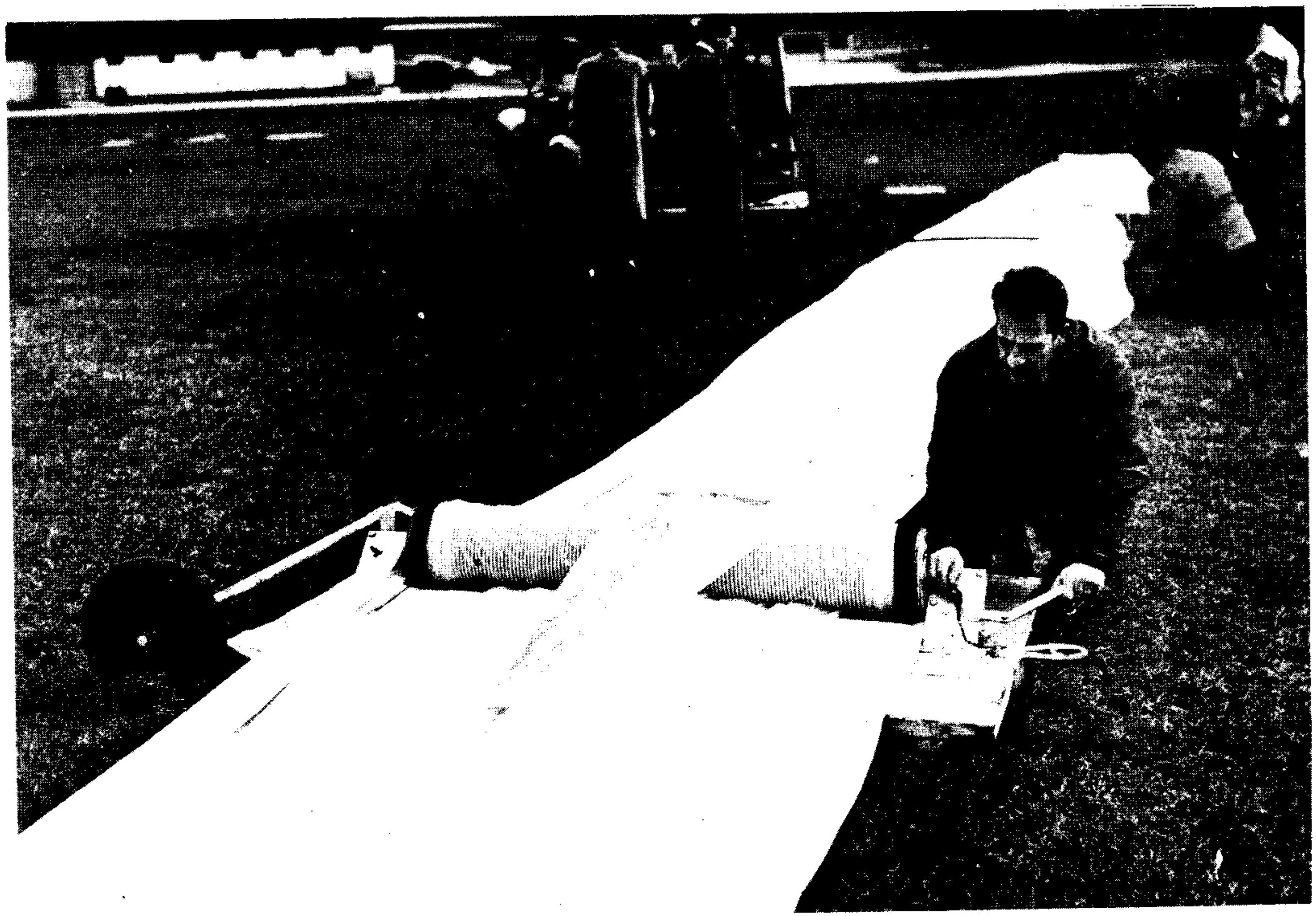


Figure 25

Launching platform with balloon fixed in place
for inflation.

the balloon and permits gas to be introduced into the top of the cell first. As the balloon is laid out and shotbags are positioned, this tube must be kept clear. At the point where the bubble is pinched off the folds of the balloon are carefully divided; the inflation tube is made as free as possible with only one layer of polyethylene above and one below it. The tube is then pulled up above and between the arms of the releasing device or the heavy shot bags, and the remainder of the fabric is pinned down so that no shifting will permit premature release.

Depending upon the load to be lifted and the rate of rise desired, a pre-computed amount of helium is fed into the balloon (see Section IV, A). This amount is determined by noting the equilibrium pressure and temperature of the gas in each cylinder. A manifold is used to feed the gas from the tanks to the inflation tube in the balloon. Shown in Figures 26 and 27 this manifold system consists of an adjustable number of flexible pigtails leading into a main line of heavy copper tubing. This main line and the fittings are capable of withstanding the full tank pressure of about 2500 feet psi. Two pressure gages are included in the main line and it is thus possible to make last-minute checks of the amount of gas (pressure) in each tank. (Due to variable gage-calibrations, it has been found necessary to establish the lift-pressure ratio of each gage before using it.) In the main line of the manifold, two valves control the gas flow. The inflation tube is often initially twisted when the balloon is first laid out, A small amount of gas at very low pressure should be valved into the tube to strengthen it. In addition to the fine valve control required for this preliminary gas feed, it is also nedessary for a manifold valve to permit high gas flow from the tanks even when the pressure is greatly reduced. For this, the coarse globe valve is used.

Once the tube has been checked, inflation should proceed as rapidly as possible. The balloon is outdoors and so subject to buffeting by the wind. The limiting factor of speed of inflation is the vibration of the fabric near the open end of the inflation tube.

As a result of the extreme cooling of the rapidly expanding gas, the manifold and the tank valve generally become coated with frost. Too rapid cooling may actually cause the valve to freeze shut.

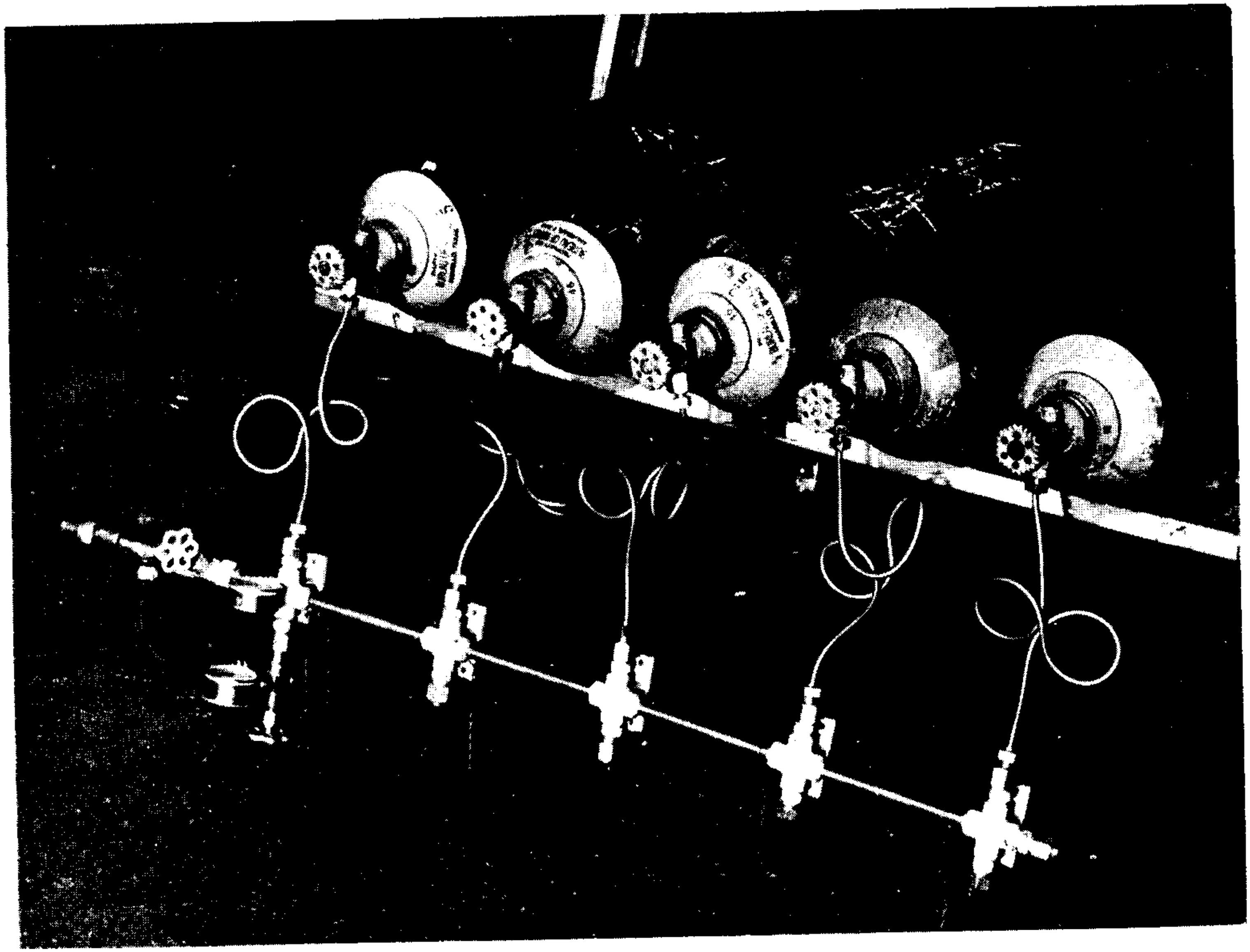
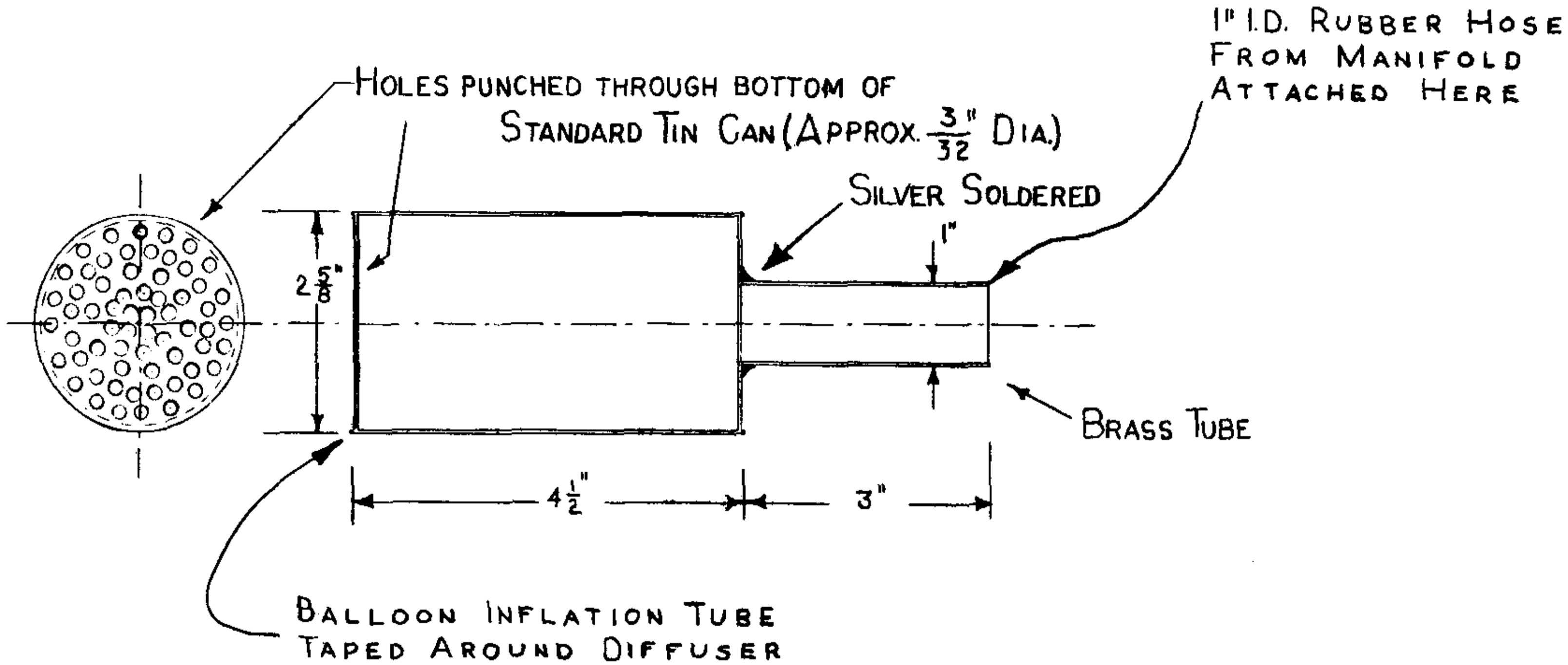


Figure 26
Five Tank Helium Manifold



SCALE 1:2

FIG. 27

NYU BALLOON PROJECT	
TYPE 2 DIFFUSER	
DATE 8-25-48	ED48-76A

JN

The effect of this cooling is evidenced in the lifting power of the gas. When a rapidly filled balloon is launched immediately after inflation, it has less lift than desired and may even be "heavy" rather than buoyant. 20°C cooling will make balloon 1% heavier. This may be 25% of free lift. In the inflation of the 70-foot balloons where more gas is used, and the cooling effect is more often harmful, a heating unit is added to the inflation equipment. The gas passes from the manifold through a coil which is centrally warmed by a blow torch and on into the inflation tube. The gas should arrive in balloon no more than 20°C cooler than the air.

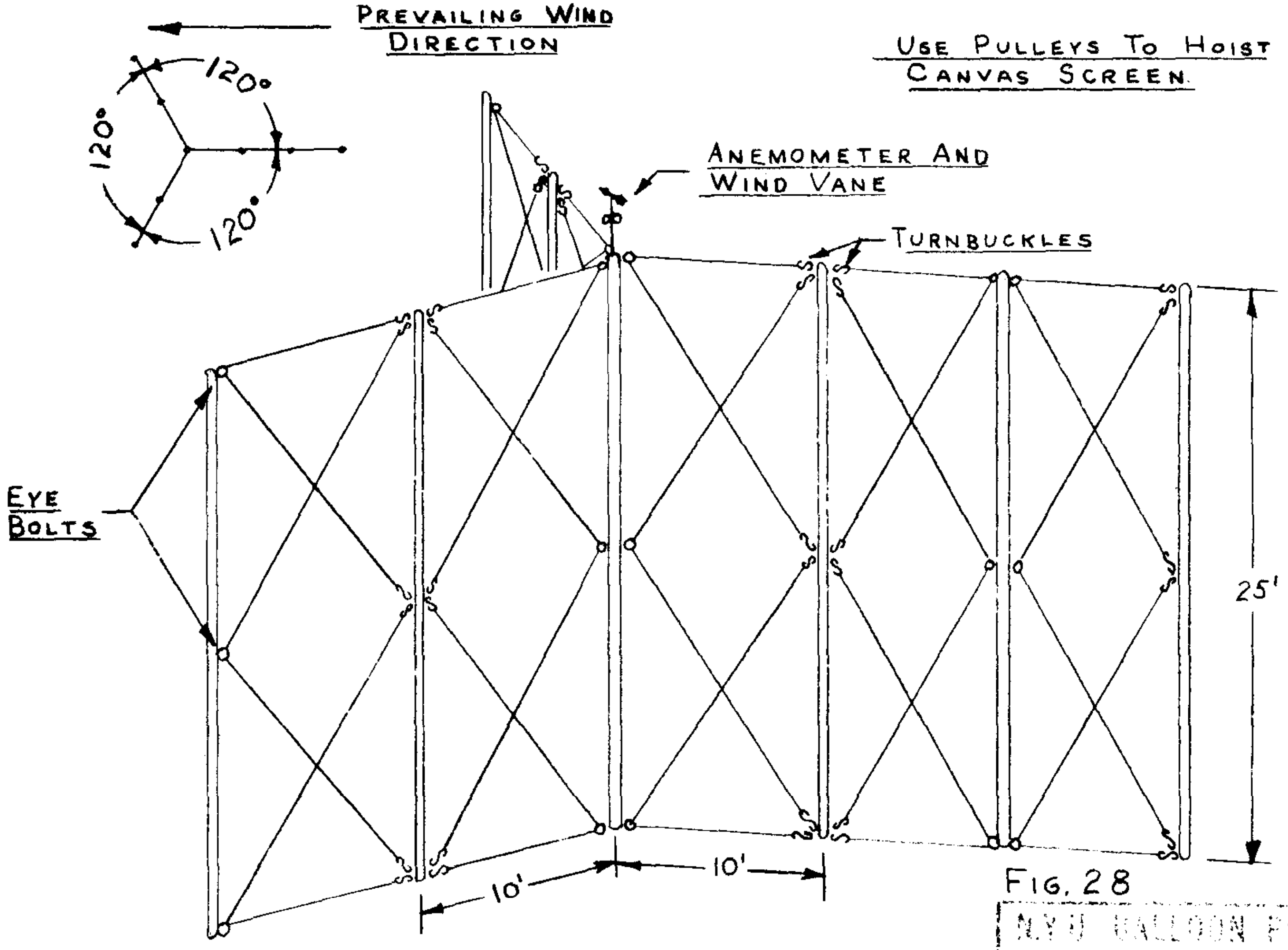
VI. BALLOON LAUNCHING

When the balloon inflation is complete, the inflation tube is removed from the balloon as gently as possible. There is apt to be constriction at the point where the bubble is formed by the launching arms or the shot bags. If the tube does stick at this point, great care must be given to freeing without ripping the balloon.

Should the balloon be torn in this or any other manner, it may be possible to patch the fabric and salvage the flight. The acetate-fiber scotch tape, used to attach the batten is used for patching. Transverse tapes are laid across the tear and the entire region is covered with a matting of tape.

When the inflation tube is freed and the restrained bubble is ready for launching, the lower portion of it is laid out down wind, as is all of the gear on the load line. The inflation is generally done in the lee of the hangar or "Y"-shaped wind screen (see Figures 28 and 29) with the bubble as close to the wall as possible. It is imperative that the wind direction be noted prior to launching and that the equipment be directly downwind from the head of the bubble. It is strongly recommended that a standard meteorological rubber balloon be inflated and tethered on a 150-foot line near the point of release to serve as a wind indicator. This balloon is much more effective than a standard wind vane.

All pieces of equipment and all on-lookers must be removed from the immediate vicinity to prevent accidental entanglement of the load line when the balloon begins to rise. Each piece of delicate gear to be carried aloft should be cradled by one man. As a signal given by the flight director (after checking to see everyone is ready and that the balloon will go in the desired direction), the bubble is released (see Figure 30). If "launching arms" are used, this is not



TELEPHONE POLES CROSS BRACED WITH STEEL CABLE TO SUPPORT CANVAS WIND SCREEN. CANVAS REMOVED AFTER USE. PERMANENT WIND SCREEN MAY BE ERECTED USING WOODEN SIDES.

FIG. 28

N.Y.U. BALLOON PROJECT

Y-SHAPED WIND SCREEN

LHM 1-25-49 ED49-3A

-48-

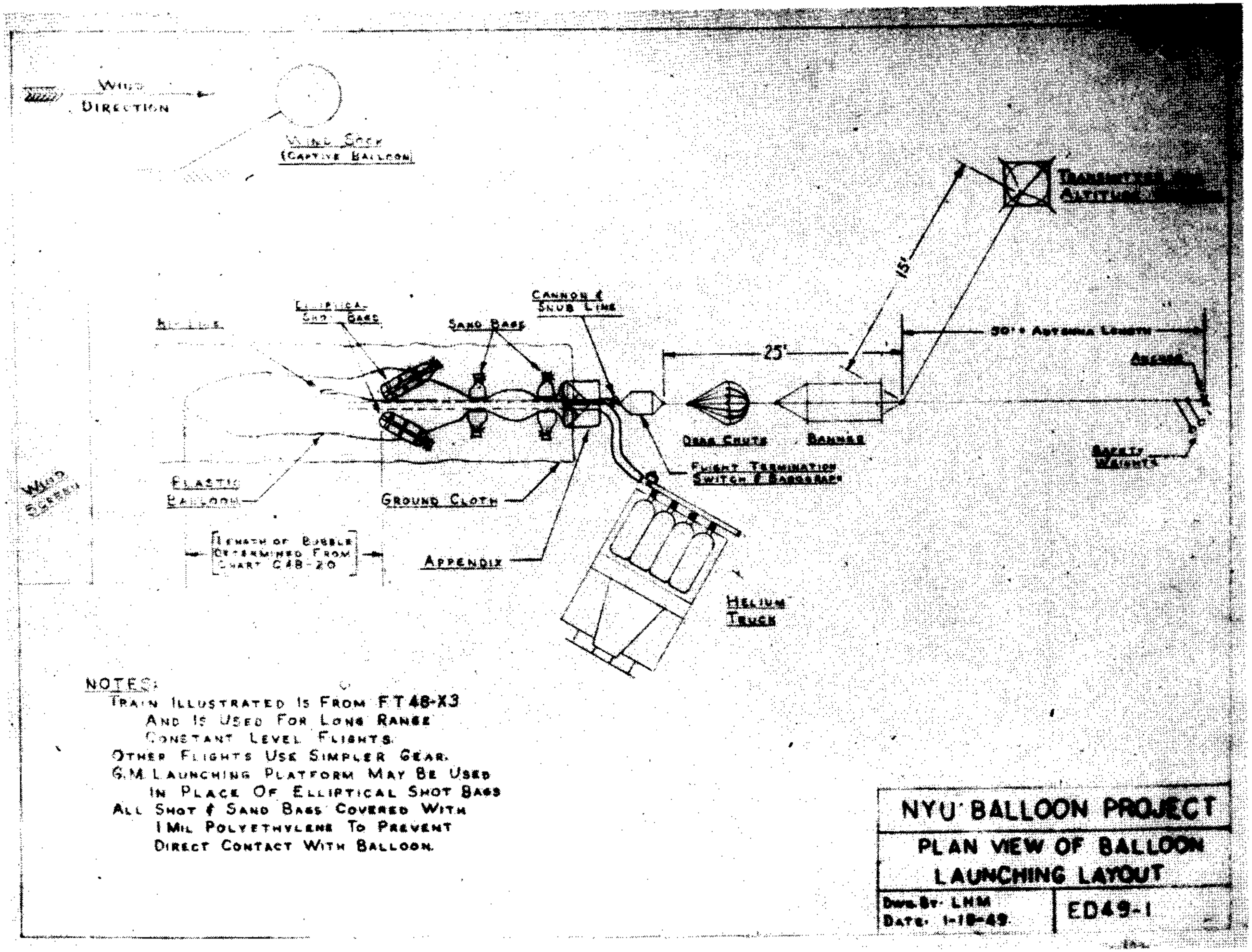

Wind Direction
Wind Sock (Captive Balloon)
15'
25'
Cannon & Snub Line
Elliptical Shot Bags
Sand Bags
Elastic Balloon
Ground Cloth
Length of Bubble Determined From Chart C48-20
Appendix
Helium Truck
Flight Termination Switch & Barograph
NOTES:
Train Illustrated Is From FT48-X3 And Is Used For Long Range Constant Level Flights.
Other Flights Use Simpler Gear.
G.M. Launching Platform May Be Used In Place Of Elliptical Shot Bags
All Shot & Sand Bags Covered With 1 Mil Polyethylene To Prevent Direct Contact With Balloon.
NYU BALLOON PROJECT
PLAN VIEW OF BALLOON LAUNCHING LAYOUT
Dwg. By: LHM
Date: 1-18-49
ED49-1

Figure 29

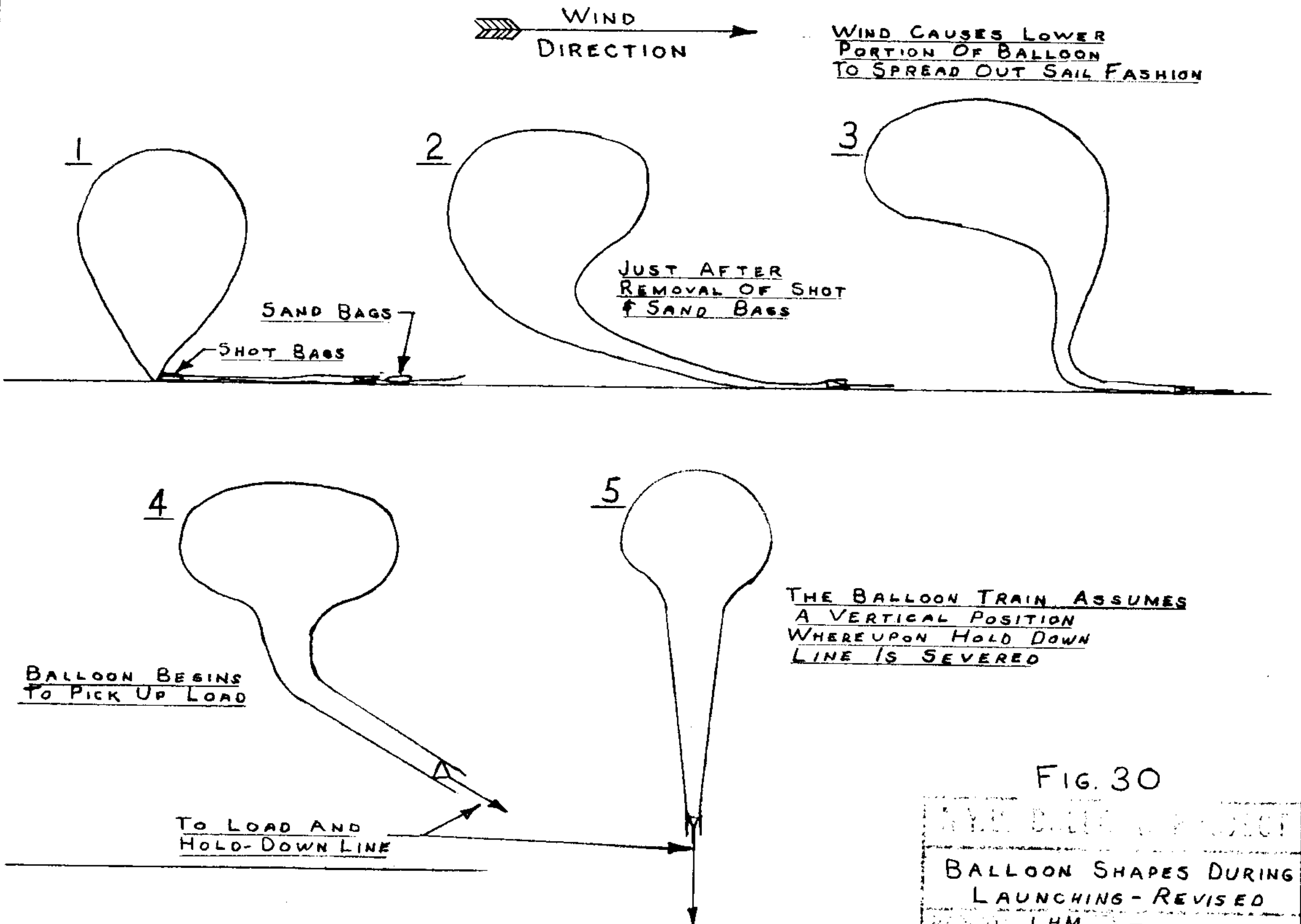


FIG. 30

BALLOON SHAPES DURING LAUNCHING - REVISED

LHM 1-28-49 ED49-4

difficult, but if the two elliptical shot bags are employed, they must be lifted simultaneously upward and outward away from the balloon. As the cell rises, each piece of gear must be cradled by its bearer allowing it to be lifted vertically when the balloon passes overhead. In many instances where the wind direction is not constant at the surface or changes as the balloon goes upward, and exact downwind positioning of launching personnel will be difficult. It is often necessary for these men to run to one side or forward or backward to get directly beneath the balloon. In cases of extreme wind speed, it has been found necessary to load the lower pieces of equipment on to a truck bed before release of balloon and launch it by driving underneath the balloon.

It is possible to estimate the space required to launch a train of given length if the wind speed is known. By using the computed figure for rate of rise, the length of time required to lift the entire train is found. The distance the bubble will travel during this time is proportionate to the wind speed. For example, if a train 250 feet long is launched with the rate of rise at 500 feet per minute, a bubble will move downwind at 660 feet if the wind is 15 miles per hour (22 feet per second), and the man at the end of the equipment train must cover 410 feet in 30 seconds carrying the gear with him.

The use of a restraining line attached to the load line above any heavy gear or delicate gear is recommended. A loop in this restraining line is attached to a winch mounted on a track a few hundred feet downwind of the lowest piece of gear, or is held by a well-gloved man. The safety weights are attached near the end of this line. The balloon tends to pull the gear in beneath itself in calm or light winds, and may pull sidewise if the train alignment is not perfectly downwind; the restraining line withstands this pull. Thus tethered, the balloon is forced to come overhead of the equipment bearers, and they are able to launch with less difficulty and danger of equipment damage. If the apparent ascent rate is too slow, the restraining line is cut between the safety weights and the other pieces of equipment. If the rate of rise appears to be high enough, the restraining line is severed below the safety weights and they rise, completing the launching.

VII. TRACKING AND ALTITUDE DETERMINATION

Following release, it is often necessary to know the position of the balloon and its height as long as possible. Several methods of position and height determination have been found useful. Advantages and limitations of each system are given.

A. <u>Positioning Equipment</u>

(1) SCR-658

The radio direction finding set SCR-658 has been found to be the most useful unit to track a balloon-borne transmitter, within its limited range. If the set is in good condition and the transmitter signal is good, it is possible to receive from a transmitter which is 150 miles away at an altitude of 50,000 feet. At this distance, the elevation angle is usually not high enough to be reliable, since below angles of 13°, ground reflection of signals makes them nearly meaningless. The azimuth angle and the elevation angle, when above 15°, are accurate to about 0.5°. It is thus necessary to use two such sets on about a 100-mile base line to give a position fix. If the elevation of the balloon is determined independently, and the elevation angle is above 13°, it is possible to locate the balloon-borne transmitter with one SCR-658.

The installation and maintenance of SCR-658 requires the services of a specially trained man, while the operation procedure may be made by relatively unskilled personnel, with limited training. For details of the use of the SCR-658, see War Department publication TM11-1158A.

(2) Theodolite

The meteorological theodolite is useful on daytime flights when skies are clear for ranges up to 100 miles. If radio data are available to give height, the additional information obtained from this instrument--elevation and azimuth angle--will completely fix the balloon's position in three dimensions. When pressure data are known, two theodolites with a base line several miles in length will also uniquely locate the balloon. A third method, less accurate but still useful, is the method of stadia measurements. By carefully measuring, prior to release, the distance between two distinctive portions of the train and then noting the angular distance subtended during flight by these instruments, the altitude and hence all coordinates of the balloon may be determined.

Regular and frequent checks must be made of the scale adjustments of the instruments and of the base plate levels when the instrument is located out of doors. For details of the use and care of theodolites, see either the War Department publication TM-11-423 or the U. S. Weather Bureau Circular "O".

(3) Aircraft Radio Compass

It has been found feasible to determine the position of the balloon by following the signal from a balloon-borne transmitter, using an aircraft radio compass as receiving unit. In this way it is possible to fly along a path toward the balloon, usually at a much lower altitude, and, by noting the plane's position where the compass reading is reversed, the position of the transmitter is found. The main disadvantage of using this system is that aircraft is needed, but there is no other method which will so readily position the balloon over great distances and periods of time. With this system, the limit of transmission time is a function of the weight of transmitter batteries which can be carried rather than distance. It is possible to power a transmitter to supply 2 watts, for about 15 hours, using 15 pounds (7 kilograms) of batteries. Longer periods of transmission may be achieved by intermittent operation of the transmitters or use of heavier batteries.

(4) Radar

If ground radar is available, accurate positioning over a limited range can be made. It is helpful but not strictly required to add radar targets (corner reflectors) to the flight train for such tracking. Using radar, the elevation angle, azimuth angle and slant distance out are obtained, giving a complete fix on the balloon with one set. The maximum distance to which appropriate sets can reach is about 65 miles; such sets are the SCR-584, the SPM-1 and the MPS-6. With good orientation and leveling such sets have an accuracy of 1.0° and about 500 feet of slant range. Because of the limited range, radar sets are not generally useful. Attempts to use radar mounted atop aircraft for aerial observation have been abandoned in favor of the radio compass.

B. <u>Altitude Determination</u>

In early attempts to utilize standard radiosonde pressure modulators they were found to be unsatisfactory. The Diamond-Hinman system of counting signal changes is not useful when the changes occur at a nearly constant altitude due to the width of the steps and the ambiguity of direction of vertical motion. Two pressure measuring systems have been found satisfactory for use in constant-level work and are discussed below. For a discussion of the radio transmitters which have been used (the standard T-69 and the NYU AM-1), see Technical Report No. 2, Balloon Project, New York University Research Division.

(1) Olland Cycle Pressure Measuring Instrument

This instrument, shown in Figure 31, is used in balloon flights as the primary pressure measuring unit, as it will continuously measure pressure without ambiguity. It modulates the transmitted radio signal at intervals whose timing is determined by the pressure of the air at the balloon's position.

As presently designed, the modulator contains a standard Signal Corps ML-310E radiosonde aneroid unit, a rotating cyclinder of insulating material with a metal helix wound around the cylinder, and a 6-volt electric motor which rotates the cylinder.

There are two contacting pens which ride on the cylinder and conduct electrical current when they touch the helix. One pen is fixed in position and makes a contact at the same time in each revolution of the helix. This contact is used as a reference point for measuring the speed of rotation of the cylinder. The time that the second one, which is linked directly to the aneroid cell, makes contact with the spiral, is dependent on the cylinder speeed and on the pen position which is determined by the pressure. By an evaluation chart, the atmospheric pressure can be determined as a function of the relative position of the pressure contact as compared to the reference thus eliminating all rotation effects but short term motor speed fluctuations.

Preparation of the modulator for flight consists of the following steps:

(a) Test the motor operation. When a 6-volt battery is inserted in the motor circuit with the proper polarity, the motor should run smoothly at one revolution per 60 to 80 seconds. Noisy operation is probably a sign of dirty or corroded

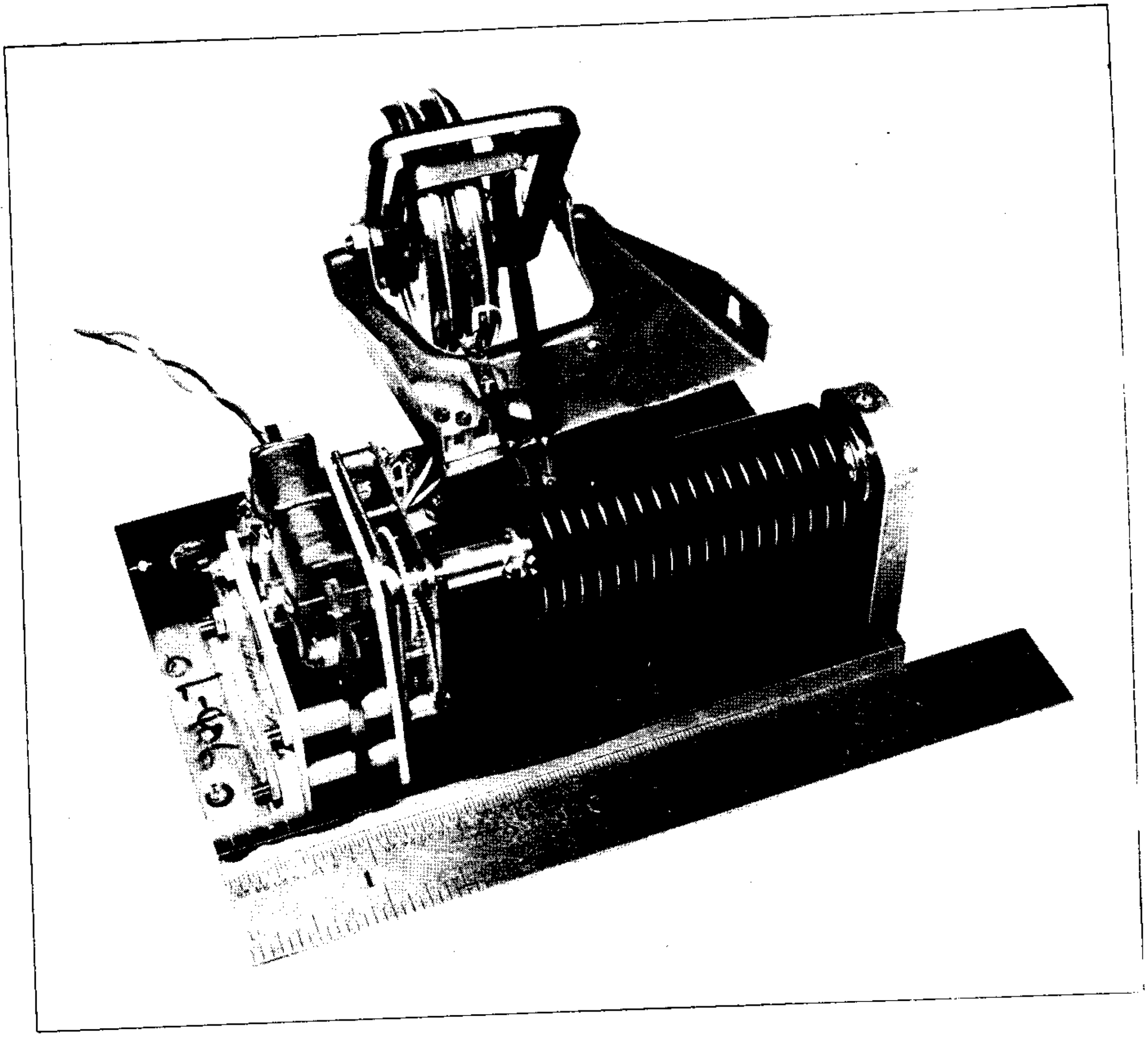


Figure 31
Olland Cycle Pressure Modulator

gears or poor alignment of the rotating cylinder. The motor gears may be cleaned with carbon tetrachloride and a small clean brush. If the trouble is due to misalignment, the instrument should not be used since this will affect the rotation at a non-uniform rate and thus destroy the entire accuracy of the record.

(b) Calibrate the instrument. The following equipment is required for the calibration:

Vacuum pump
Bell jar
Base plate with at lest 4 electrical leads
Manometer
Tape recorder

The vacuum pump should be capable of evacuating the bell jar to a pressure lower than that to be reached by the balloon in flight. A pressure of ten millibars, corresponding to about 100,000 feet elevation is usually a good minimum.

Four wires are necessary to conduct the six volts to the motor and to transmit the reference and pressure signals. The wires must pass out of the bell jar through an air-tight seal in the base plate. The base plate also needs a tube leading to the manometer and a tube to the vacuum pump. It is advisable to use two separate tubes rather than placing the manometer lead in the same line as the pump lead in order to obtain the pressure in the bell jar rather than that in the pumping line.

In operation the negative line of the battery leads is used as the ground connection of the output signal.

A tape recorder such as the Brush Development Co. model BL-902 oscillograph and amplifier BL-905, is needed to record the signal both during calibration and during the balloon flight. The Brush recorder is used at present and the discussion of the operation will be made in terms of the characteristics of this instrument. When using the slow speed of the recorder, which feeds the paper at the rate of 30 centimeters per minute, the distance between successive reference marks will be 30 to 40 centimeters depending upon the speed of rotation of the modulator motor. The pressure signal appears at any point along the record between or overlapping the references depending upon the pressure. A sample record of this sort is shown in Figure 32.

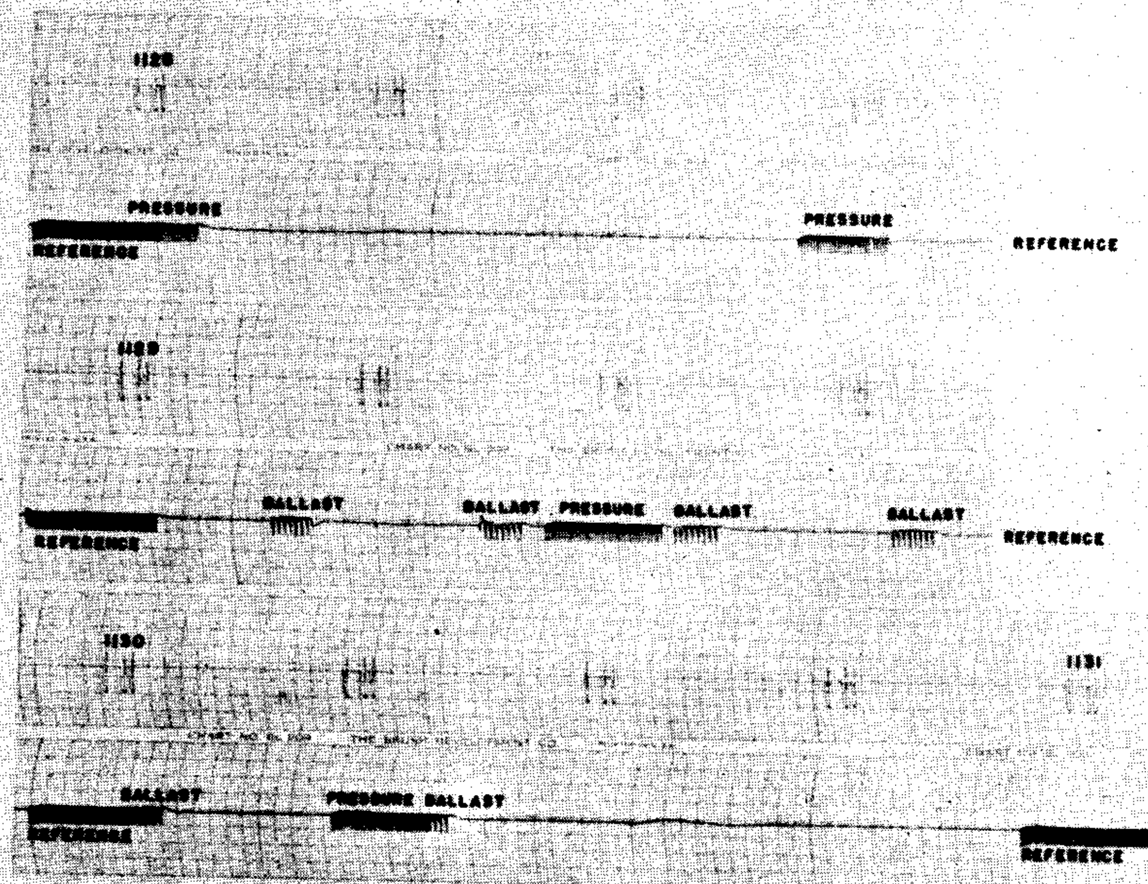
The Olland cycle acts as a switching unit for the test oscillator (see Figure 33) whose signal is fed into the Brush amplifier and finally to the recorder. By adjusting the resistors in the test circuit, the frequency of oscillation may be adjusted. Since within the usual range, the frequency of oscillation is approximately additive when the two signals overlap, the suggested frequencies are about 4 cycles per second for pressure and 8 cycles per second for reference. When overlapping signals are being recorded the frequency will be about 12 cycles per second which is easily recognizable on the record.

The calibration of the modulator unit should be in steps of 25 to 30 millibars in order to have at least three points within each turn of the helix.

Evaluation of the record is accomplished with the aid of a nomogram divided into 100 equal parts. The record is laid on the nomogram with the leading edge of the first reference on the zero line and the leading edge of the second reference on the 100th line. The position of the leading edge of the pressure signal is then read to the nearest third of a division on the nomogram. If one complete turn of the spiral represents 75 millibars, it is thus possible to read the pressure to an accuracy of one-three-hundreth of 75 or about one-quarter millibar.

In evaluating the record the tape should be kept parallel to the horizontal lines on the nomogram or perpendicular to the zero line in order to avoid errors in interpretation.

The total motion of the pen arm of the modulator is normally 12 to 14 turns of the spiral. Therefore, there will be the same number of points at which the pressure and reference signals overlap. The calibration curve (Figure 34) is drawn to show pressure from zero to surface pressure (about



Sample Record Of Olland Cycle Pressure Modulator Signal As Recorded On Brush Oscillograph

Reference— 9 cps
Pressure — 5 cps
Ballast — 2.5 cps

Time Signal Every 15 Seconds On Channel 2.

C 49-6
Feb. 25,1949-LHM

Figure 32

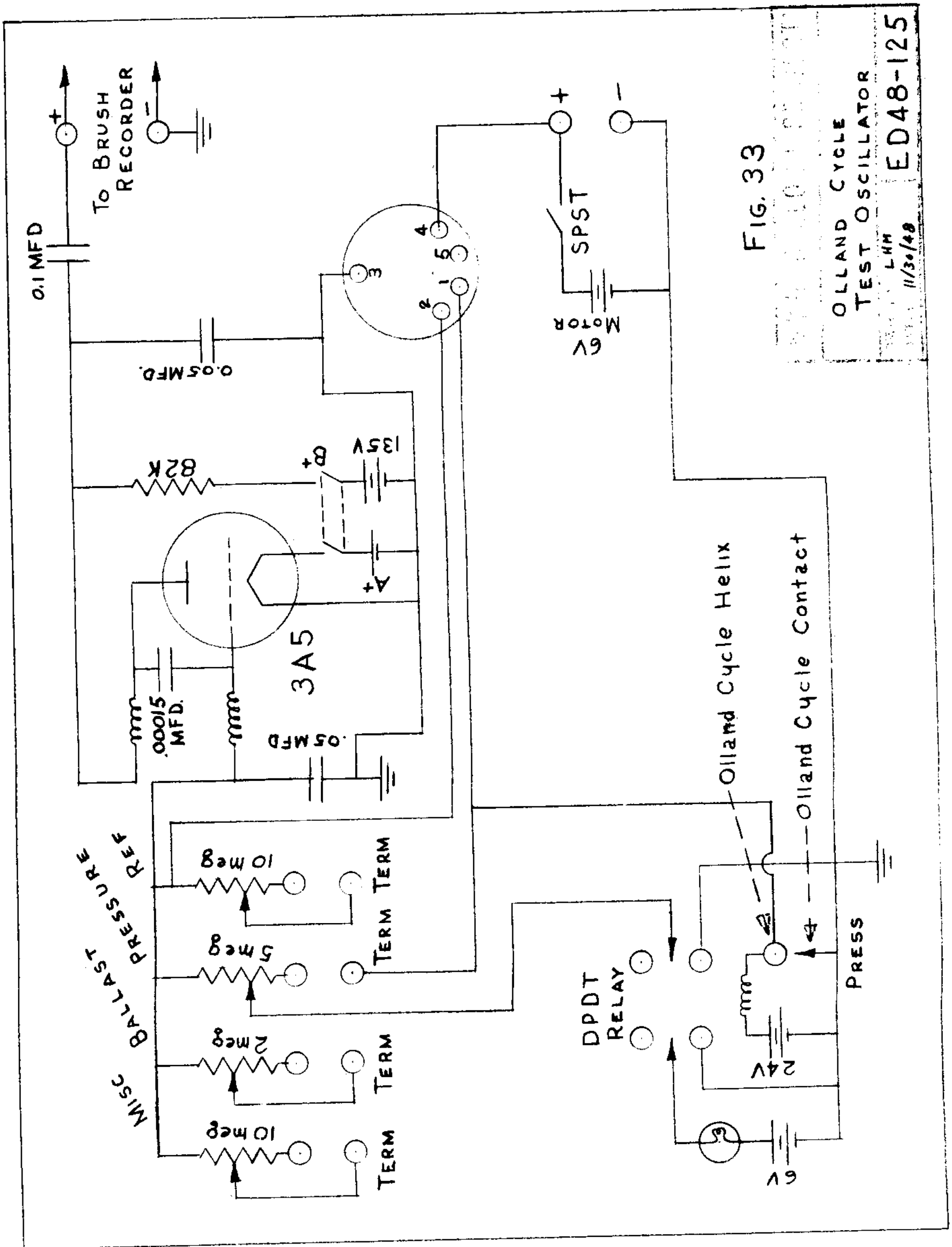

To Brush Recorder
+
−
0.1 MFD
0.05 MFD.
82K
B+
135V
A+
3A5
.00015 MFD.
.05 MFD
6V Motor
SPST
+
−
1
2
3
4
5
Olland Cycle Helix
Olland Cycle Contact
Press
DPDT Relay
24V
6V
Misc
Ballast
Pressure
Ref
10 meg
5 meg
2 meg
10 meg
Term
Term
Term
Term
Term
Olland Cycle
Test Oscillator
LHM
11/30/48
ED48-125

Fig. 33

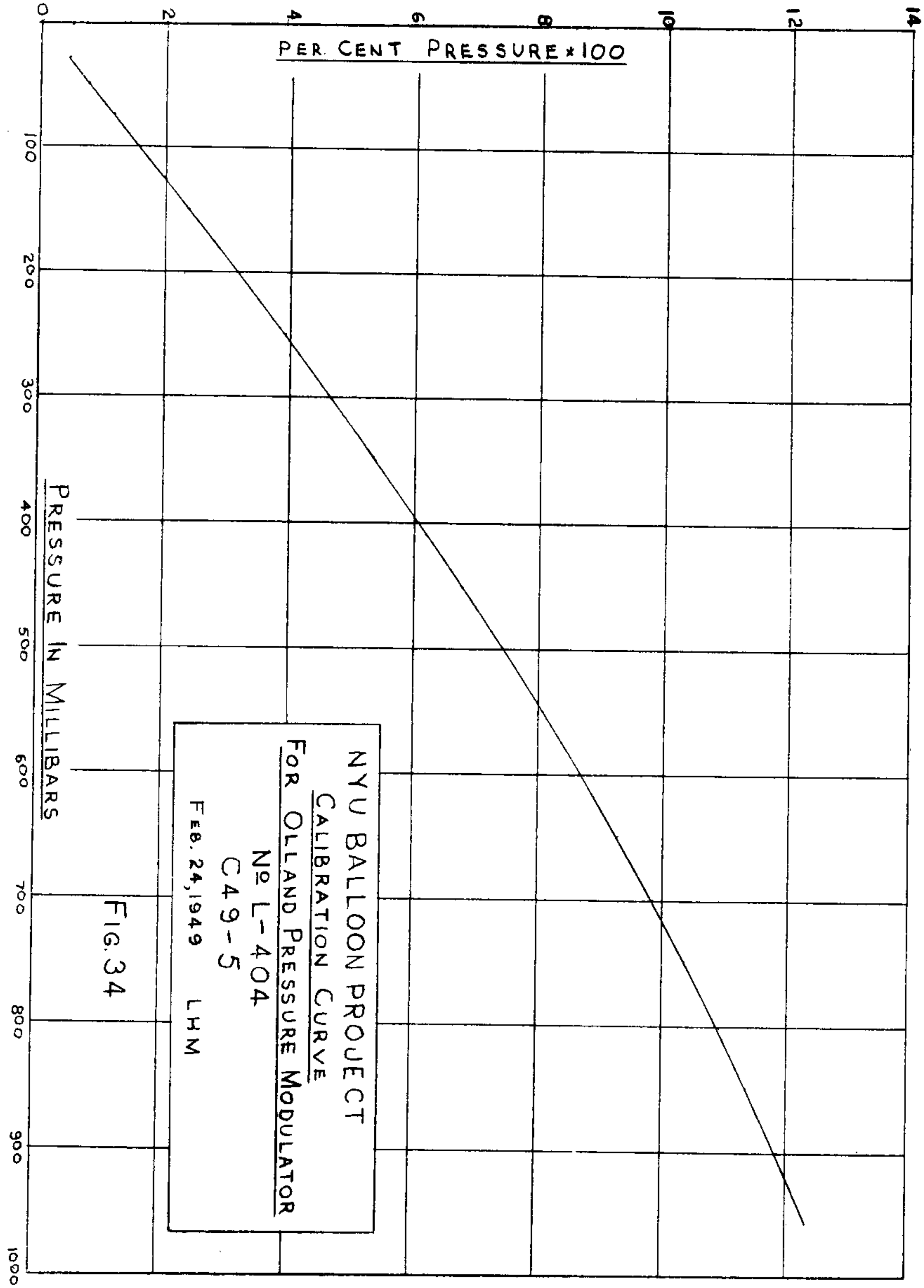

PER CENT PRESSURE × 100
PRESSURE IN MILLIBARS
0
2
4
6
8
10
12
14
100
200
300
400
500
600
700
800
900
1000
NYU BALLOON PROJECT
CALIBRATION CURVE
FOR OLLAND PRESSURE MODULATOR
No L-404
C49-5
FEB. 24, 1949 LHM

FIG. 34

1020 millibars) against percentage of the turns as read on the nomogram. The lowest pressure reading is numbered as read and succeeding pressures are plotted in a continuous ascending series. When the pressure reading reached the first overlap on the reference, it is called 100 percent; the second overlap is 200 percent and so on until the last overlap which may be 1200 or 1300 percent.

(c) Pack the modulator and insert it inside the transmitter box. The modulator should be protected from extreme cold since the motor operation becomes erratic when the temperature reached 30° to 40°C below zero. A box or paper cover over the modulator will keep particles of insulation and dirt from the moving parts.

(d) When the entire assembly has been made and inflation of the balloon is about to begin, the transmitter and motor should be turned on and reception of the signal tested. If any serious trouble appears, the modulator should be replaced by another calibrated modulator since any work on the instrument will probably change the calibration.

During the flight, radio static and noise will appear on the Brush record as pips which may resemble the transmitted signals and with increasing distance or weakening transmitter the noise will finally completely obscure the pressure record. Careful tuning of the receiver will prolong the record as long as possible. When tuning the receiver, the sensitivity control of the Brush amplifier should be turned to the least sensitive position since any sudden change in the tuning may throw the pen off its supports and damage its glass tip.

When the flight reception is completed the record is evaluated exactly as in the evaluation of the calibration record--using the same nomogram. However, since the instrument is subjected to different atmospheric conditions, the motor speed may vary suddenly, giving false values for the pressure. These values may be detected by carefully observing the rate of rotation of the motor, which is measurable by the distance between the reference marks. If there is a sudden change in motor speed of five percent or more from the preceding rotation, the pressure value should be rejected. A slow, continuous change in speed from minute to minute may be neglected since it is probably a uniform change throughout the rotation period. The motor speed will decrease during the flight, as a result of the low temperatures and the drop in battery voltage. This of itself does not decrease the value of the record, as long as the speed does not change suddenly.

(e) Olland-Cycle Pressure Element Specifications

(1) Pressure range: 1050 to 5 mb.

(2) Desired accuracy: Surface to 300 mb ±5 mb.
300 mb to 50 mb ±2 mb.
50 mb to 5 mb less than ±2 mb, ±1 mb if possible.

Highest accuracy and readability desired on low pressure end. Temperature compensation, as required to meet pressure accuracy requirements for temperature, range +30° to -70°C or equivalent for medium and high altitude flights. Mean operating temperature required more than 0°C.

(3) Helix:

<u>Cylinder</u>--made of insulating material with low temperature coefficient.
Diameter 3/4 inch to 1 inch, length 2¼ inch.

<u>Spiral</u>--made of nickel or other metal which does not corrode in the atmosphere, .010 inch or less in diameter.
Eight turns per inch on cylinder.

<u>Check-points</u>--Six points located between turns of spiral, starting with 9th turn, 60 degrees apart.
Made of the same material as the spiral.
In the electrical circuit of the pressure signal.
Suggested shape 1/16 inch diameter, round pin, flush with surface of helix.

General--Helix mounted in a rigid frame to prevent lengthwise movement or springing out through bending of a frame.
Joined to motor drive by a pin through both drive shaft and helix shaft.
When rotating at about 1 rpm duration of signals not over 3 to 4 seconds.
Surface of helix to be polished with rouge or crocus cloth.
Loading edge of the metal spiral will be true and smooth to within .0005 inch.

(4) Motor:

6 to 7.5 volts
1 rpm gear train
20 to 40 milliamperes drain
Constant speed--change of speed during any single revolution not more than 0.3%
Speed change at low temperature not more than ±20%

(5) Mounting of Unit:

Mounting in such manner that temperature changes and stresses will not change the relative positions of the aneroid and the helix. This may be done by mounting all elements on a $\frac{3}{4}$" metal plate or by mounting all parts in a frame supported on a single pedestal.

Mount unit in an easily opened, stiff single thickness cardboard or plastic box to protect it from other units in flight trains.

External terminal strip with four terminals connected to ground, motor, reference, and pressure.

Total weight not over 500 grams.

Overall dimension not over 5 x 5 x 4 inches.

To be mounted in transmitter, where insulation will prevent cooling below 0°C within 6 hours at air temperature of -40° to -50°C.

(2) Codesonde

The modified radiosonde built by Brailsford and Co., Rye, New York, called the codesonde, has been found valuable when knowledge of small variations in the height of the balloon is not required. Using this system, a radio transmitter is modulated by a Morse code signal which is a function of pressure (and temperature if desired). This system is useful for tracking a balloon with aircraft since no recording equipment is necessary for data interperlation.

Each combination of dots or dashes may be identified by ear, and with a calibration chart, the pressure which corresponds to the balloon's height may be thus determined by anyone who can read Morse code with a suitable radio receiver. The advantages of using this system for a balloon which is to be followed by aircraft include the fact that it is necessary to receive only one complete code group to completely identify the pressure level of the balloon. It is thus possible to interrupt the period of reception without permanently losing the altitude record. It is expected that a balloon transmitter which can be followed with an aircraft radio compass will be used in conjunction with this pressure modulator, giving three-dimensional position data.

(3) Barograph

Many balloon flights pass out of the range of even a network of receiving stations. When it is not possible, because of weather or other considerations, to follow the balloon with aircraft, a clock-driven meteorograph may be added to the flight train to record data, such as pressure and temperature. It is necessary to recover the balloon equipment to evaluate this sort of record. With inland release points, it has been possible to recover about 75% of all flights.

The model U-48 Lange barograph, shown in Figure 35, is designed to give a record of atmospheric pressure and the temperature of the barograph case. In order to obtain a maximum spread of the pressure record in the range at which the data is most useful, the linkages are arranged so that recording begins at about 500 millibars or around 19,000 feet, and may be continued as high as the balloon rises. The

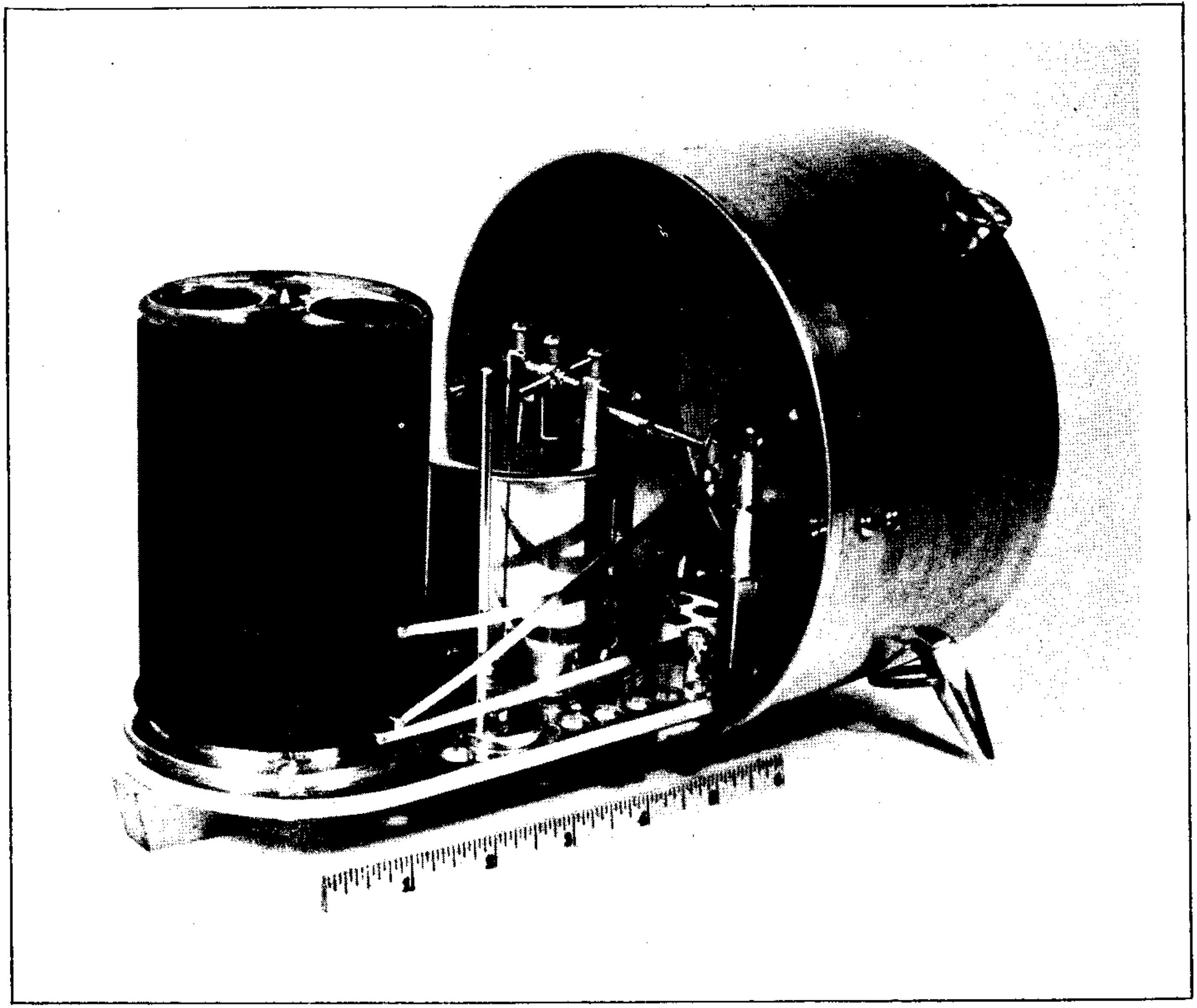


Figure 35
Lange Barograph Thermograph With
Smoked Foil on Recording Drum

temperature recording is confined to the lower 2 inches of the drum so as to interfere as little as possible with the pressure record when the balloon floats above 30,000 feet.

Recording is accomplished by three pens which scratch carbon from a smoked aluminum foil. This method eliminates the need for liquid ink and applies a minimum of pressure to the recording drum.

The recording drum rotates once in twelve hours. Therefore, if a flight lasts over twelve hours, the trace will overlap. Such a record is shown in Figure 36. The clock runs for 36 to 40 hours on one winding.

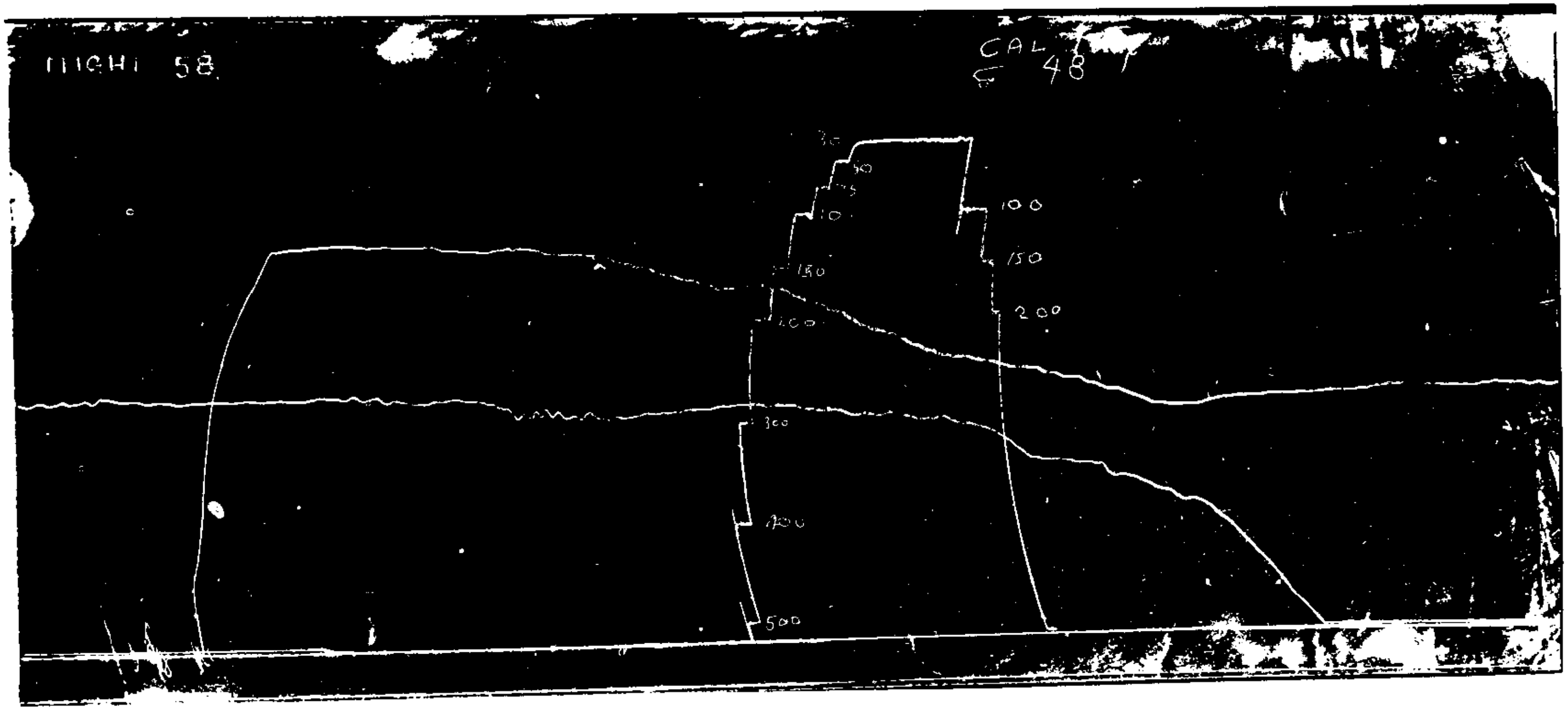
Preparation of the barograph for use on a balloon ascension requires the following:

(a) Place an aluminum foil about 10 inches long by 3 3/4", .002" thick on the drum. Care should be taken to have the overlapping edge of the foil face in the direction of rotation of the drum so that the stylus slides off the edge instead of catching and tearing the foil. A few drops of rubber cement along each edge of the foil are sufficient to fasten the foil to the drum and will not interfere with removal of the foil after recovery of the barograph.

(b) Wind the clock. The clock should not be wound tightly since at the low temperatures encountered in the upper atmosphere the clock spring may snap. However, if the clock is wound an hour or so before release, it will be sufficiently relaxed by the time the low temperatures are reached.

(c) Check pressure of the marking pens. Too much pressure of the pens on the drum will introduce an error due to the frictional lag. When the drum is removed from the clock mechanism, and the pen lifter released, the stylus points should touch the clock housing lightly.

(d) Smoke the drum. A very thin, fine-grained carbon film should be deposited on the aluminum foil. The best result will be obtained by use of a bright yellow gas flame, although a kerosene flame gives a satisfactory coating. Solid or liquid



NYU BALLOON PROJECT

Barograph Record

FLIGHT 58

Released at Alamogordo, N.M. May 10-1948 2033 M.S.T., Recovered at Val D'or, Quebec, Canada

(Orifice Ballast-Leak 300gm/hour)

Duration $24\frac{1}{2}$ hours

Figure 36

fuels usually give a coating which is too coarse grained and heavy. In smoking the drum a long rod is used as a rotating axis. The drum is rotated rapidly in the flame so as to prevent overheating and oxidizing of the foil. The carbon should not be so thick as to obscure the metallic appearance of the aluminum foil.

(e) Calibrate the barograph for pressure. The instrument is placed in a bell jar and the air evacuated. The pressure is kept constant at a number of pressures so that as the drum turns a step, record is made on the smoked foil. Pressure recording starts at about 500 millibars so the first level in the calibration should be at that value. At each level the pressure should be kept constant for three to five minutes in order to obtain a measurable line. Great care and considerable practise are required to control the valves of the vacuum system so that the pressure does not change noticeably during each step.

The pressure steps at which the barograph is calibrated may be either at regular pressure intervals or at the pressure values corresponding to regular height intervals according to the standard atmosphere figures. The recommended steps are listed below. If the balloon is not expected to go to the higher altitudes, the calibration may be stopped at correspondingly higher pressures.

Pressures	Standard Atmosphere Heights			
500 mb	466 mb	corresponding	to	20,000 ft.
400 mb	300 mb	"	"	30,000 ft.
300 mb	188.5 mb	"	"	40,000 ft.
200 mb	117 mb	"	"	50,000 ft.
150 mb	72.8 mb	"	"	60,000 ft.
100 mb	45.3 mb	"	"	70,000 ft.
50 mb	28.2 mb	"	"	80,000 ft.
10 mb	17.5 mb	"	"	90,000 ft.
	10.9 mb	"	"	100,000 ft.

The temperature calibration may be made by recording two widely spaced temperatures, such as room temperature and the temperature of dry ice (-78°C). This celibration will be approximately a straight line and, therefore, two points are sufficient to plot the curve.

Immediately before the balloon release, when the clock is wound and the pens lowered against the drum, the pressure and temperature pens should be tapped lightly so as to make short marks and the time noted.

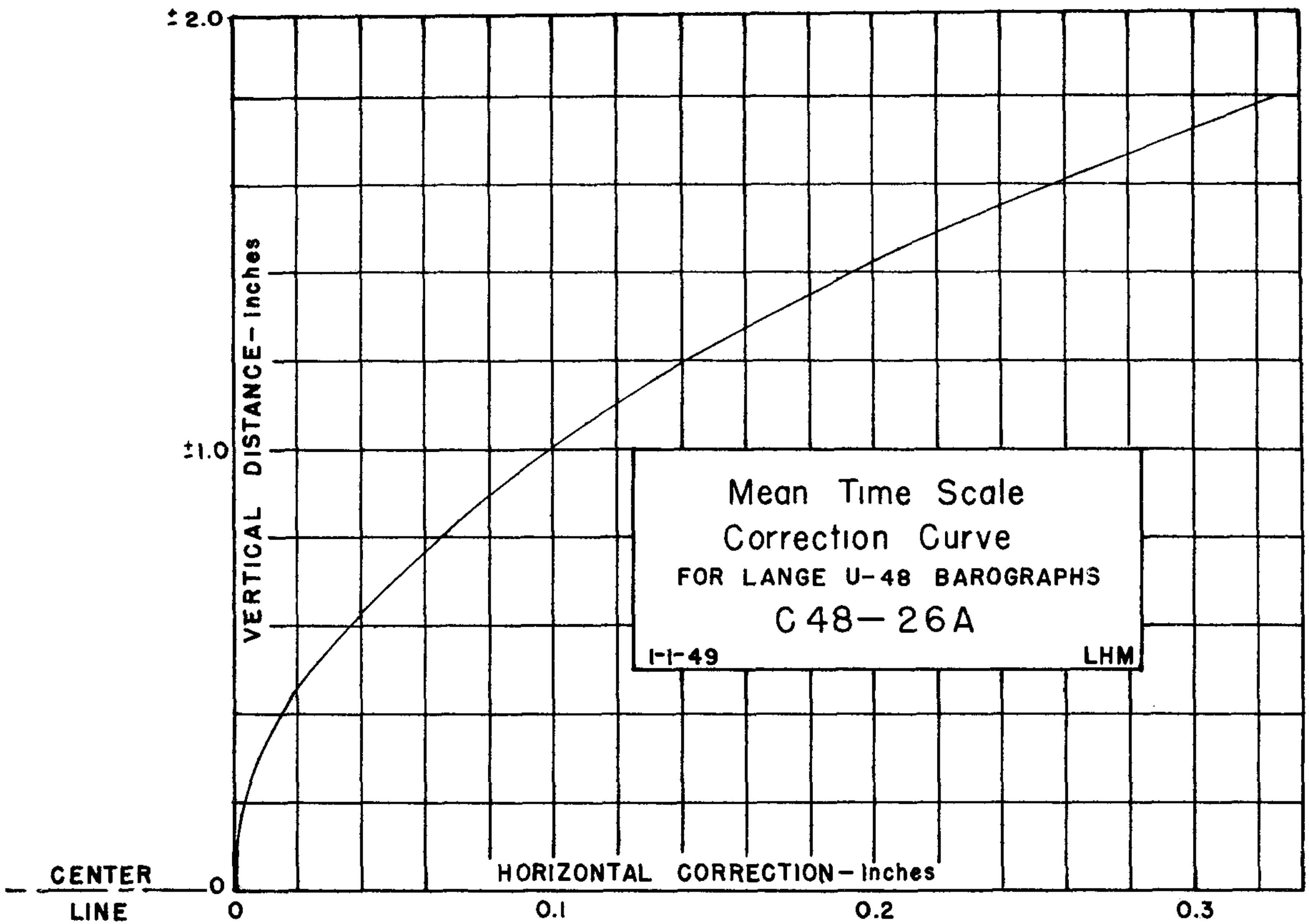
When the barograph is recovered the smoked foil should be treated to preserve the record. A solution of clear shellac diluted with about ten times its volume of alcohol may be used. The drum is immersed in the shellac and allowed to dry thoroughly before further handling.

(f) Evaluation of the record. In evaluating, the record heights of significant points are measured vertically from the reference line. The pressure calibration steps are measured first and plotted on graph paper, vertical distance versus pressure or altitude. Each significant point on the flight trace is then measured and the corresponding altitude determined from the calibration curve.

The same procedure is followed in evaluating the temperature record, measuring from the reference line.

The curvature of the record due to the motion of the pens must be corrected for. Since the temperature record covers a short vertical range, the time correction may be neglected. Corrections for curvature of the pressure record may be read directly from Figure 37, which gives the correction in inches as a function of the distance of the point in question from the center of the record.

The final time correction is made to correlate the temperature and pressure records. This may be done by measuring the horizontal distance between the temperature and pressure marks as made before release and correcting this amount for vertical position. The rotation of the drum is once in 12 hours and, therefore, the time-distance relation may be computed by noting the total length of record obtained in one revolution.



±2.0
±1.0
0
VERTICAL DISTANCE - Inches
HORIZONTAL CORRECTION - Inches
CENTER LINE
0
0.1
0.2
0.3
Mean Time Scale
Correction Curve
FOR LANGE U-48 BAROGRAPHS
C48-26A
1-1-49
LHM

FIG. 37

VIII. ANALYSIS

During and following the flight it is customary to analyze the behavior of the balloon. Two curves are usually drawn when data is available for their preparation. The first of these is a time-height curve which gives the altitude of the balloon at all times with respect to sea level. On this curve also it is customary to plot the temperature data and ballast flow data when such has been recorded. In some cases it has been found useful to plot a profile of the terrain over which the balloon is passing. The second diagram usually prepared is the trajectory of the balloon, and again it may be prepared with respect to the terrain over which the balloon was passing. That is to say, it is plotted on an aircraft map of the area, with positions and heights plotted every ten minutes. Figures 38 and 39 show sample plots.

IX. GENERAL MILLS 7-, 30-, AND 70-FOOT BALLOONS

The altitudes reached and loads which may be carried by the General Mills balloons other than the 20-foot cell are shown in Table 4, Appendix II. Graph 3, Appendix II may be used for interpolation of the tabulated values to give the relationship between floating altitude and gross load, and Graph 4 shows the altitude sensitivity at various heights. It has been assumed that helium is the lifting gas. Graph 1, Appendix II is useable for all of these balloons to determine the amount of free lift which is needed to give a desired rate of rise.

To launch a 7-foot balloon, it is not necessary to utilize the elaborate technique of the larger balloons. A can of sand is made to weigh the same amount as the required gross lift (equipment weight plus free lift), and attached to the load ring. Inflation from a single tank may be made inside any building with relatively large doors and when the balloon just lifts the inflation weights it may be attached to the equipment line, carried outdoors and released. In light winds the equipment may be released with a hand-over-hand paying out of the line. If there is too much wind for this method, the equipment is laid out downwind and the balloon released so as to pass over the pieces of gear and pick them up while rising.

A 7-foot balloon being inflated is seen in Figure 40. The appendix which is shown is made of a flattened 2-foot length of inflation tube, from a 20-foot balloon, without stiffeners. Such a balloon has been sustained with a fixed ballast leak

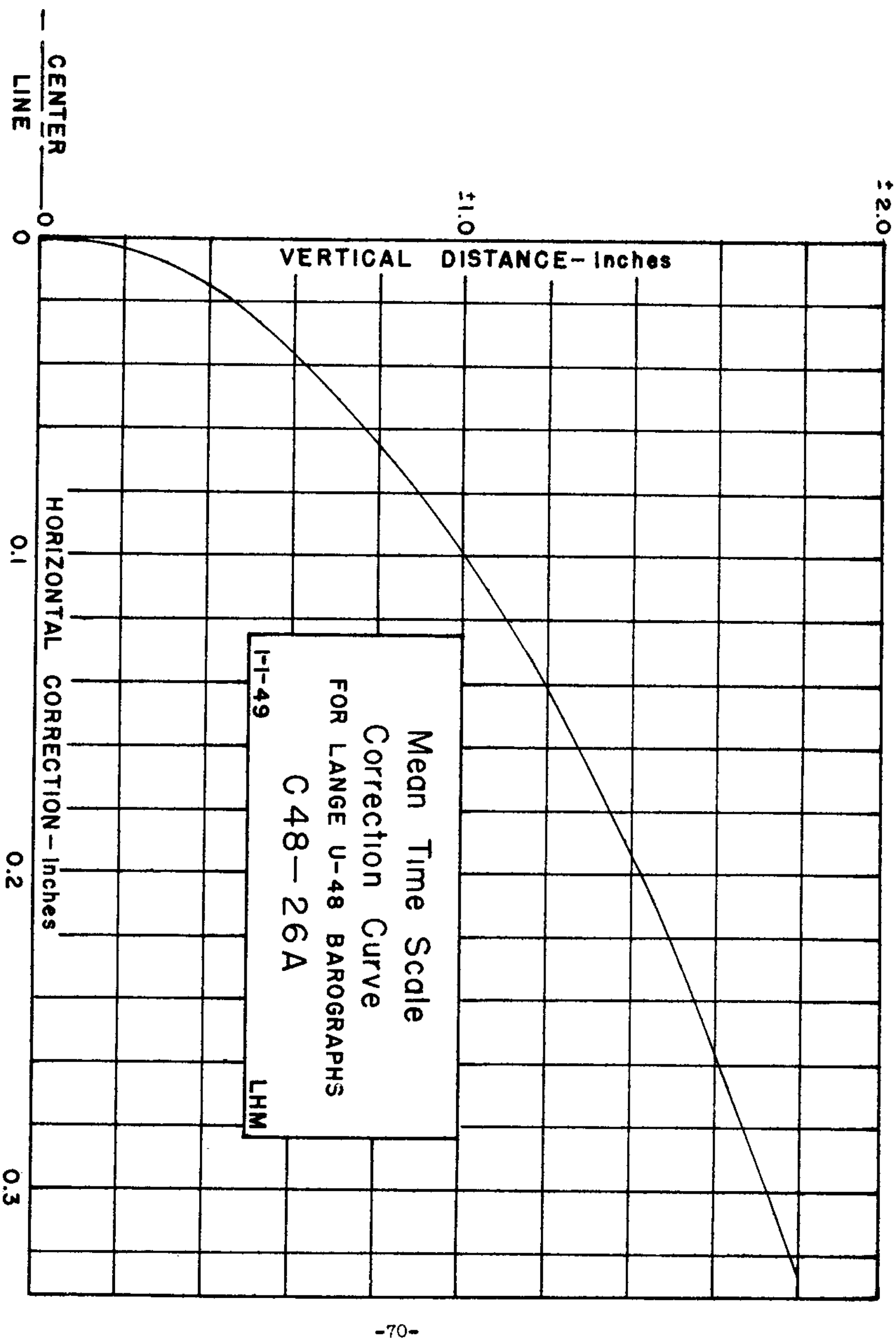

CENTER LINE
VERTICAL DISTANCE-Inches
±1.0
±2.0
HORIZONTAL CORRECTION-Inches
0
0.1
0.2
0.3
Mean Time Scale
Correction Curve
FOR LANGE U-48 BAROGRAPHS
C 48-26A
1-1-49
LHM

FIG. 37

VIII. ANALYSIS

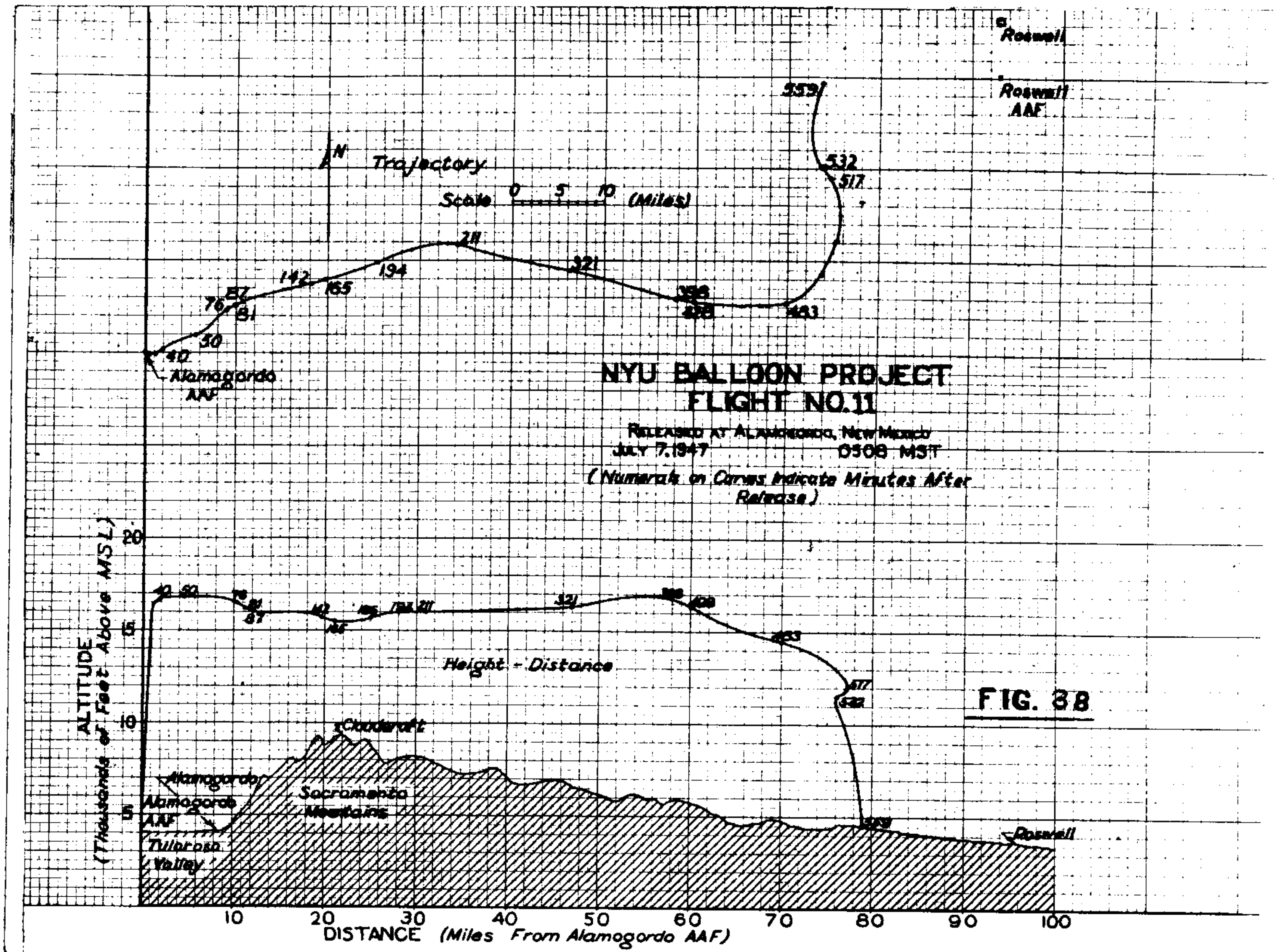
During and following the flight it is customary to analyze the behavior of the balloon. Two curves are usually drawn when data is available for their preparation. The first of these is a time-height curve which gives the altitude of the balloon at all times with respect to sea level. On this curve also it is customary to plot the temperature data and ballast flow data when such has been recorded. In some cases it has been found useful to plot a profile of the terrain over which the balloon is passing. The second diagram usually prepared is the trajectory of the balloon, and again it may be prepared with respect to the terrain over which the balloon was passing. That is to say, it is plotted on an aircraft map of the area, with positions and heights plotted every ten minutes. Figures 38 and 39 show sample plots.

IX. GENERAL MILLS 7-, 30-, AND 70-FOOT BALLOONS

The altitudes reached and loads which may be carried by the General Mills balloons other than the 20-foot cell are shown in Table 4, Appendix II. Graph 3, Appendix II may be used for interpolation of the tabulated values to give the relationship between floating altitude and gross load, and Graph 4 shows the altitude sensitivity at various heights. It has been assumed that helium is the lifting gas. Graph 1, Appendix II is useable for all of these balloons to determine the amount of free lift which is needed to give a desired rate of rise.

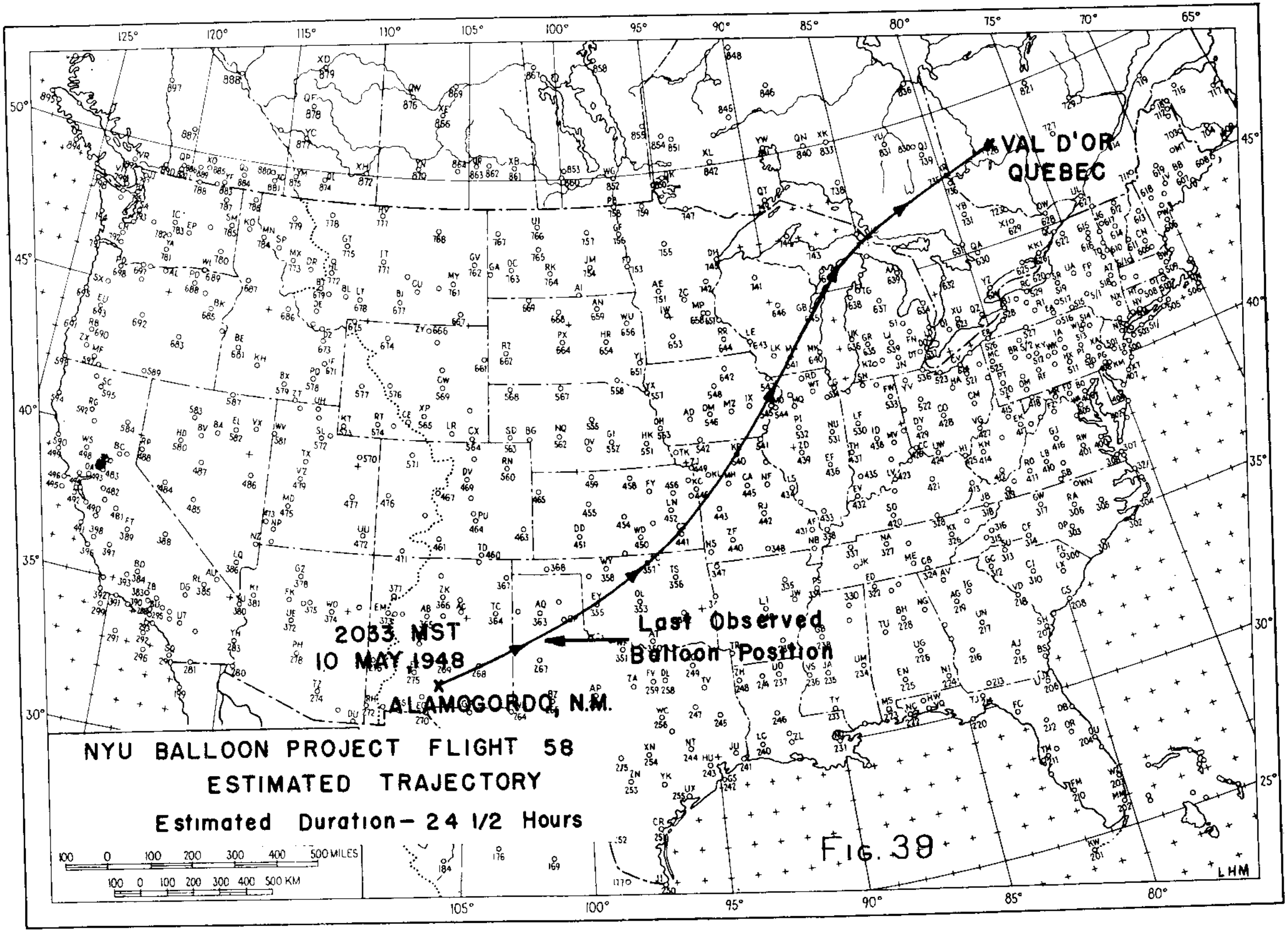
To launch a 7-foot balloon, it is not necessary to utilize the elaborate technique of the larger balloons. A can of sand is made to weigh the same amount as the required gross lift (equipment weight plus free lift), and attached to the load ring. Inflation from a single tank may be made inside any building with relatively large doors and when the balloon just lifts the inflation weights it may be attached to the equipment line, carried outdoors and released. In light winds the equipment may be released with a hand-over-hand paying out of the line. If there is too much wind for this method, the equipment is laid out downwind and the balloon released so as to pass over the pieces of gear and pick them up while rising.

A 7-foot balloon being inflated is seen in Figure 40. The appendix which is shown is made of a flattened 2-foot length of inflation tube, from a 20-foot balloon, without stiffeners. Such a balloon has been sustained with a fixed ballast leak



NYU BALLOON PROJECT
FLIGHT NO.11
RELEASED AT ALAMOGORDO, NEW MEXICO
JULY 7, 1947 0508 MST
(Numerals on Curves Indicate Minutes After Release)
Trajectory
Scale 0 5 10 (Miles)
N
Alamogordo AAF
Roswell
Roswell AAF
Height - Distance
Cloudcroft
Alamogordo
Alamogordo AAF
Tularosa Valley
Sacramento Mountains
Roswell
FIG. 38
ALTITUDE (Thousands of Feet Above MSL)
DISTANCE (Miles From Alamogordo AAF)

Figure 38



NYU BALLOON PROJECT FLIGHT 58
ESTIMATED TRAJECTORY
Estimated Duration – 24 1/2 Hours

FIG. 39

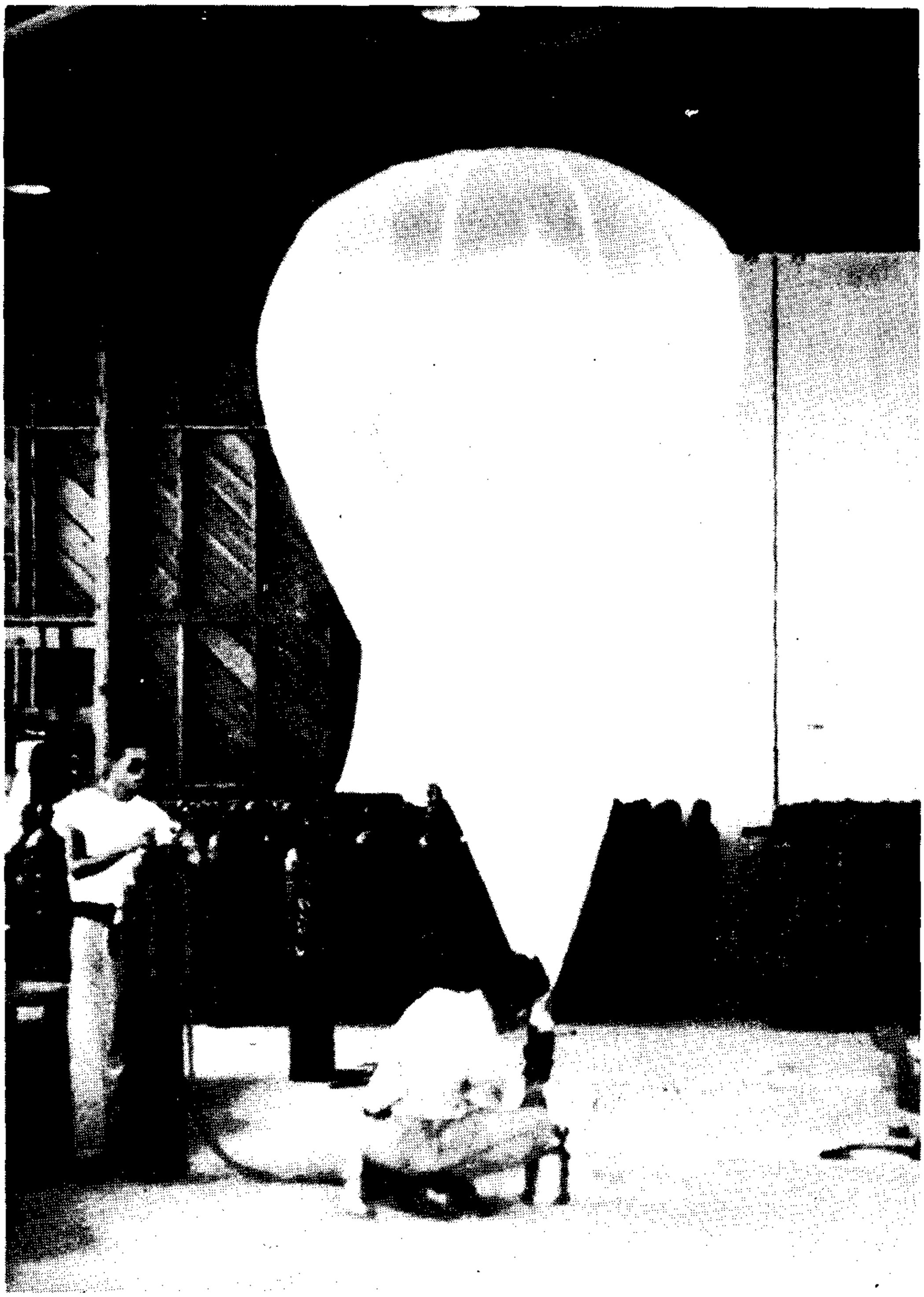


Figure 40
General Mills 7 foot
balloon being inflated.

of 170 grams per hour. A balloon of this type with no altitude control stayed aloft for more than two hours and after reaching ceiling, the altitude did not vary by more than 1500 feet while the balloon was within range of the observing station.

The preparation and launching techniques discussed for the 20-foot balloon apply also to the 30-foot cell. No further discussion is required for the 30-foot balloon.

The 70-foot balloon seen in Figures 41 and 42 is launched in the same manner as the 20-foot cell. A much larger amount of gas is required and since it is valved rapidly into the balloon, it has been found necessary to pass the gas through a heating coil to prevent it from reaching the balloon so adiabatically cooled as to be incapable of lifting the load. This heater is shown in Figure 43. Due to the large lift and area exposed to the wind at launching, the large cell may be dangerous if personnel attempt to hold the gear or act as anchors. If possible, all gear should be laid out downwind to be picked up from the ground by the balloon. The anchor should be a winch mounted on a truck which can move around the balloon so as to be downwind at launching.

Since the altitudes where the 70-foot balloons normally float are high in the stratosphere, the natural stability of the balloon in the temperature inversion keeps these cells up for a long period of time without ballast or other controls. One such flight fell slowly during a period of 75 hours and was still above 65,000 feet when the barograph record ended.

Figure 41
Inflation of 70 foot diameter
General Mills balloon.

Figure 42
General Mills 70 foot balloon
being launched in a 5 knot wind.

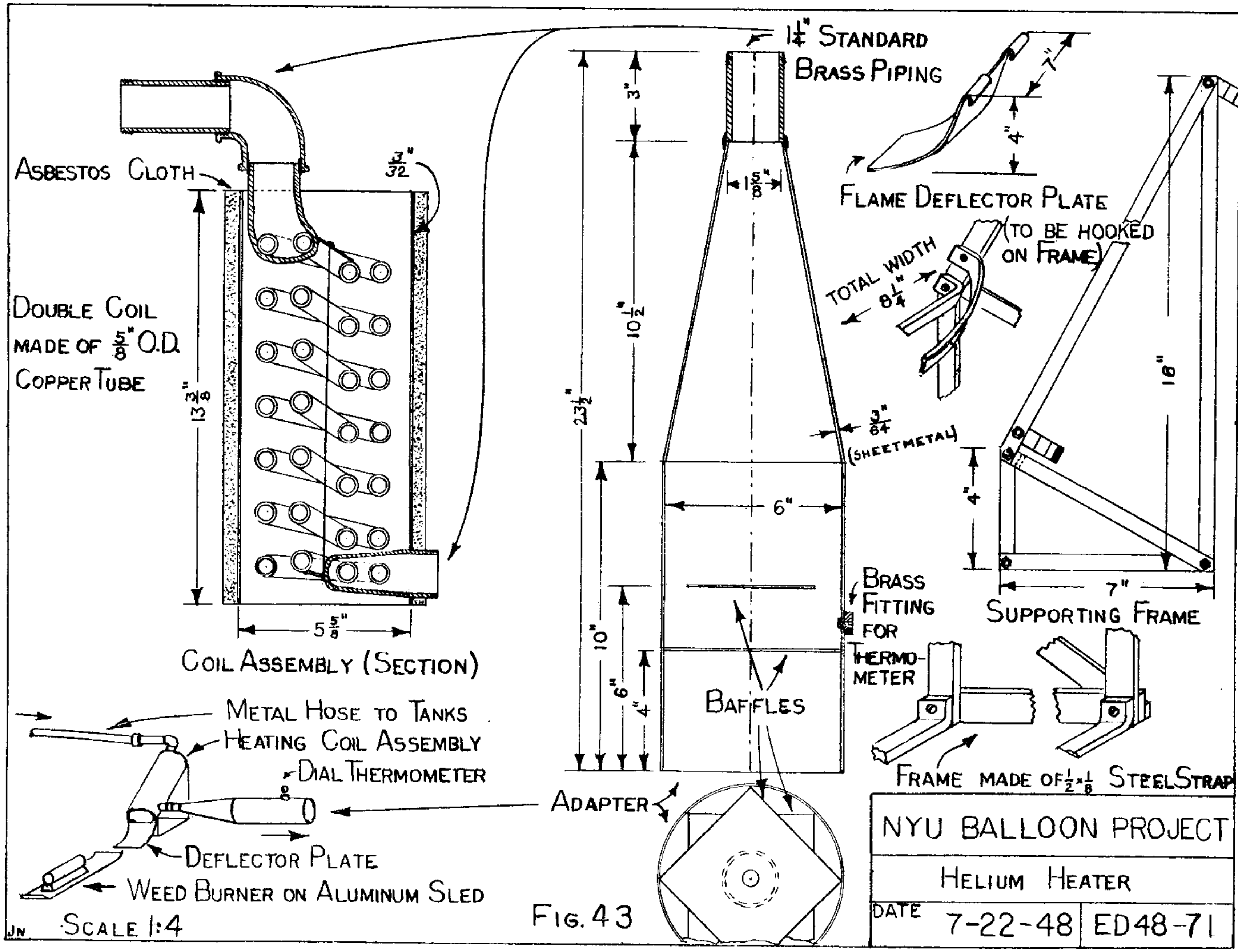

1¼" Standard Brass Piping
Asbestos Cloth
3/32"
Double Coil made of 5/8" O.D. Copper Tube
13 3/8"
5 5/8"
Coil Assembly (Section)
3"
10½"
23½"
1 5/8"
3/64" (Sheetmetal)
6"
10"
6"
4"
Brass Fitting for Thermometer
Baffles
Adapter
Flame Deflector Plate
7"
4"
Total Width 8¼"
(To be hooked on Frame)
18"
4"
7"
Supporting Frame
Frame made of ½×⅛ Steel Strap
Metal Hose to Tanks
Heating Coil Assembly
Dial Thermometer
Deflector Plate
Weed Burner on Aluminum Sled
JN
Scale 1:4
NYU BALLOON PROJECT
Helium Heater
Date 7-22-48
ED48-71

Fig. 43

GLOSSARY

Altitude Sensitivity: The altitude gained by a balloon when its load is reduced by one kilogram.

Balloon Inflation: Gas inflation to be given the balloon in terms of initial lift of the balloon (equals weight of equipment load plus free lift plus allowance for gas losses before launching).

Ceiling: The locus of pressure altitudes at which a non-extensible balloon will float when gas losses are slightly over-compensated for by ballast losses.

Equipment Load: Weight of all equipment, rigging, and ballast hung from the balloon shrouds not including balloon or its integral parts.

Floor: The locus of altitudes at which a balloon will float when lift losses are exactly compensated for on a demand basis by ballast dropping. In practice, this is determined by the operation of the automatic ballast release and is some altitude below the ceiling.

Free Lift: Net lift of the balloon with the equipment load attached.

Gross Lift: Lift of all of the gas in the balloon at release (equals weight of the balloon, equipment load plus the free lift).

Gross Load: Load on the gas at release (balloon plus equipment load weight).

Pressure Altitude: The altitude at which a non-extensible balloon becomes fully inflated.

Pressure Height: The height above mean sea level as determined from pressure measurements used in this work with the N. A. C. A. Standard Atmosphere.

Appendix I

Table 1

BASIC EQUIPMENT FOR FIELD TRIPS
LAUNCHING OF 20' BALLOONS
WITH SIMPLE CONTROL GEAR

GROUND EQUIPMENT:	NYU Balloon Project Drawing No. or Figure No. in Operations Manual
1 ea. Set instructions (Operations Manual)	
2 ea. Elliptical shot bags (each filled with 100 # of shot)	ED-48-62
2 ea. 40 # Sand bags	ED-48-122A
4 ea. 40 # Sand bags	
1 ea. 40' x 6' Ground Cloth	
4 ea. Sheets polyethylene, .001" to .004", 4' x 4'	
1 ea. 5 Tank manifold with pressure gages and valve	Figure 26
1 ea. Rubber hose, 1" I.D., 10' long	
1 ea. Gas diffuser	ED-48-76A
2 ea. Rubber tubing $\frac{1}{2}$" bore, 1/8" wall, 8' long	
2 ea. Hose clamps, aeroseal, $1\frac{1}{4}$" I.D.	
3 ea. Hose ends for helium tanks	ED-48-80
1 ea. Box white chalk	
1 ea. Solution balance Fisher #2-100	
1 ea. Inflation nozzle, ML-196	
3 ea. Weems plotters	
1 ea. Set aircraft maps of area	
1 ea. Tool kit complete with 2 sheath knives, 50' cloth measuring tape, brass wire, 1" Mystic tape, volt ohmmeter, pliers, screwdrivers, inflation tools, flashlights, crescent wrenches,	

	NYU Balloon Project Drawing No. or Figure No. in Operations Manual
(Tool kit, cont'd.) soldering iron, compass, 2 open-end wrenches 1-1/8" x 1-1/4" openings, 14" pipe wrench, spanner for helium tank valves	
2 ea. Theodolite ML-247 with tripod ML-78	
2 ea. Recorder, Brush oscillograph or other	
2 ea. Standby power units	
2 ea. SCR-658 Radio direction finder or 2 ea. Hammerlund Super-Pro receiver 2 ea. Kytoon with spare bladders for antenna support 2 ea. Captive balloon, Dewey & Almy N4	
4 ea. Chronometers	
4 ea. Clip boards	
2 ea. Complete set of communication equipment Telephone account	
Wind screen, 30' x 20', Y-shaped, equipped with flood lights and anemometer	ED-49-3

FLIGHT GEAR:

2 to 5 Tanks helium	
1 ea. General Mills 20' balloon (or other balloon to be used) plus spare	
24 ea. Rolls acetate fiber scotch tape	
3 ea. Appendix stiffeners (if appendix is to be used)	ED-48-95A
1 ea. 200' 500 # Test nylon line	
1 ea. 100' 75 # Test linen twine	
2 ea. 350 Gram balloon ML-131A (for wind sock)	
5 to 10 Toggles or hooks	

	NYU Balloon Project Drawing No. or Figure No. in Operations Manual
2 ea. Parachutes ML-132	
1 ea. Banner, 3' x 6'	ED-48-56
4 ea. Data sheets	
4 ea. Weight sheets	
4 ea. Reward tags (English, Spanish or other language)	Figure 21
2 ea. "Danger Fire" tags	Figure 20
2 ea. Other Danger tags as required	

<u>If Flight Termination gear is to be used:</u>

1 ea. Flight termination switch	ED-48-70A
1 ea. Set rip rigging	ED-48-68A
2 ea. Cannons	ED-49-5
2 ea. Squibs Du Pont S-64 (treated for high altitude)	

<u>If fixed rate ballast release is to be used:</u>

1 ea. Orifice spinnerette, to give ballast flow of 250 gm/hr (.008" D.)	ED-48-75A
1 Gallon ballast, compass fluid AN-C-116	
1 ea. Ballast reservoir (1 gallon capacity)	ED-48-79A
1 ea. Filter 3" diameter, 325 x 325, phosphor bronze mesh	ED-48-54A
4 feet Tubing (Tygon) ½" bore	
6 inches Tubing (Tygon) 3/16" bore	
Metal beakers or rimless 1 qt. tin cans	
Metal funnel	

Table 2

WEIGHT SHEET

Flight No.__________ Date__________

Time__________

Balloon Manufacturer__________ Weight__________
Number__________

Appendix or valve __________ __________

Shrouds . . . . __________

Total Balloon Weight . . . . __________

Launching Remnant . . . . __________

Line Length . . . . __________

1st Unit. Serial No. __________

description __________ __________

Line length __________ __________

2nd Unit. Serial No. __________

description __________ __________

Line length __________ __________

3d Unit. Serial No. __________

description __________ __________

Line length __________ __________

4th Unit. Serial No. __________

description __________ __________

Drag chute __________ __________

Banner description __________ __________

Ballast assembly - description __________ __________

____

____

____

Ballast . . . . __________

Total Equipment Weight . . . . __________

Gross Load . . . . __________

RATE OF RISE AND MAXIMUM ALTITUDE COMPUTATIONS

Flight No.____________________ Date____________________

Time____________________

BALLOON INFLATION

Desired Rate of Rise . . . . ____________________ ft./min.

Gross Load . . . ______________ grams

Free Lift - from Rise chart ______________ grams

Free Lift $= \frac{V}{412}\ {}^{2}G^{2/3}$ __________________ grams

Equipment Weight __________________ grams

Desired Balloon Inflation = Free Lift + Equipment Total ____________ grams

Allowance for Leakage @ ______________ gm/hr., _______ hrs. waiting ____________ grams

Actual balloon lift . . . . ____________ "

AActual gross lift (Balloon lift & balloon wt.) . . . . . . ____________ "

Number Helium tanks required at _____ kg lift/full tank . . . ____________ tanks

Length balloon above shot bag . . . . ____________ feet

---

MAXIMUM ALTITUDE

Balloon Volume . . . . ____________________ cu. ft.

Gas Lift/mol . . . . Helium 11.1 kg/mol; Hydrogen 12.0 kg/mol

Molar Volume $= \frac{\text{Balloon volume x gas lift/mol}}{\text{gross load}}$

____________________ cu. ft.

Maximum Altitude . . . . ____________________ ft. m.s.l.

Altitude Sensitivity . . . . ____________________ ft./kg.

BALLAST COMPUTATIONS FLIGHT #__________

Balloon Surface Diffusion {measured / estimated} gm/hr. o/o Inflation __________ o/o

Full balloon surface diffusion - balloon surface diffusion (o/o Inflation) 2/3 __________ gm/hr.

Estimated full Balloon ceilin diffusion - F. B. Surface Diffusion $\times \frac{\text{Ceiling Pr.}}{\text{Surface Pr.}}$ ________ gr/hr.

Description of Ballast Unit: (components, serial nos. Dimensions)

Amount of Ballast ________________ gm.

Initial flow, maximum head ____________ gm./min.

Maximum flow, maximum head ____________ gm./min.

Estimated Ballast duration $\frac{\text{Amount of ballast}}{\text{Full balloon ceiling diffusion}}$ __________ hrs.

Size Orifice used ________ in. Waiting time before release ______ min.

Size Limiting Orifice used __________ in.

Size filter used ____________ in.

Initial Head to valve or orifice __________ in.

Final " " " " " __________ in.

New York University
Research Division
Balloon Project

Supplementary Information for Flight No. ____________

Release: Site ____________________ date ______________ time ______________

Encoded Sounding Data:

Encoded Upper Winds

Release Weather

In-Flight Hourly Weather

Train Sketch in Folder ________________________ Films Sent Out ____________

List Flight Records in Folder:

Remarks

Checked by ______________________________

Transmitter Performance for Flight No. ______________________________

Release: Date_________ Time____________________ Site_____________

Transmitter Type and Serial No.______________________________
Batteries: Type and Number ______________________________

Open Circuit Voltages:

Voltages Under Load:

Description of Pressure Unit

Description of Special Equipment

Reception at Station #2

Reception at Station #3

Critique

Appendix II

PRESSURE AND TEMPERATURE

IN THE N.A.C.A. STANDARD ATMOSPHERE

December 1948

Prepared by

Irwin Brill
Research Assistant

Balloon Project
Research Division
New York University

Under Contract W28-099-ac-241 with
Watson Laboratories, A.M.C., U.S. Air Forces

Source Pressure from surface (0 feet) to 65,000 feet: taken from National Advisory Committee for Aeronautics Report #538, and corrected as noted below.

Pressure from 65,000 feet to 163,538 feet: taken from National Advisory Committee for Aeronautics Report #1200.

Temperatures at 1000-foot intervals, taken from National Advisory Committee for Aeronautics Reports #538 and 1200.

Geopotential Assumptions for pressure corrections:

0 feet to 30,000 feet based upon assumed constant geopotential.

30,000 feet to 65,000 feet corrected for geopotential, by approximate correction factors. (Taken from extrapolated curve of difference in feet, from 65,000 to 100,000 feet, between N.A.C.A. table #538 (uncorrected) and N.A.C.A. Technical Note #1200 (corrected).

65,000 feet to 163,538 feet, corrected for geopotential by National Advisory Committee for Aeronautics, Note #1200.

Accuracy Surface to 30,000 feet ± 15 feet, assuming constant geopotential.

30,000 feet to 65,000 feet	± 30 feet
65,000 feet to 100,000 feet	± 50 feet
100,000 feet to 120,000 feet	± 100 feet
120,000 feet to 135,000 feet	± 150 feet
135,000 feet to 163,538 feet	± 250 feet

Table 1

PRESSURE (MB) VERSUS HEIGHT (FEET)

MB	ALT.	DIF.	MB	ALT.	DIF.	MB	ALT.	DIF.	MB	ALT.	DIF.
1015	-47	27	969	1228	28	922	2593	29	875	4002	31
1014	-20	27	968	1256	28	921	2622	29	874	4033	31
1013.25	0	27	967	1284	28	920	2651	29	873	4064	31
1013	7	27	966	1312	28	919	2680	29	872	4095	31
1012	34	27	965	1340	28	918	2709	29	871	4126	31
1011	61	27	964	1368	28	917	2738	29	870	4157	31
1010	88	27	963	1396	28	916	2767	29	869	4188	31
1009	115	27	962	1424	28	915	2796	29	868	4219	31
1008	142	27	961	1452	28	914	2825	29	867	4250	31
1007	169	27	960	1481	29	913	2854	29	866	4281	31
1006	198	27	959	1510	29	912	2883	29	865	4312	31
1005	223	27	958	1539	29	911	2912	29	864	4343	31
1004	250	27	957	1568	29	910	2942	30	863	4374	31
1003	277	27	956	1597	29	909	2972	30	862	4405	31
1002	304	27	955	1626	29	908	3002	30	861	4436	31
1001	332	28	954	1655	29	907	3032	30	860	4467	31
1000	360	28	953	1684	29	906	3062	30	859	4498	31
999	388	28	952	1713	29	905	3092	30	858	4529	31
998	416	28	951	1742	29	904	3122	30	857	4560	31
997	444	28	950	1761	29	903	3152	30	856	4591	31
996	472	28	949	1790	29	902	3182	30	855	4622	31
995	500	28	948	1829	29	901	3212	30	854	4653	31
994	528	28	947	1858	29	900	3242	30	853	4684	31
993	556	28	946	1887	29	899	3272	30	852	4715	31
992	584	28	945	1916	29	898	3302	30	851	4746	31
991	612	28	944	1945	29	897	3332	30	850	4777	31
990	640	28	943	1974	29	896	3362	30	849	4808	31
989	668	28	942	2003	29	895	3392	30	848	4840	32
988	696	28	941	2032	29	894	3422	30	847	4872	32
987	724	28	940	2061	29	893	3452	30	846	4904	32
986	752	28	939	2090	29	892	3482	30	845	4936	32
985	780	28	938	2129	29	891	3512	30	844	4968	32
984	808	28	937	2158	29	890	3542	30	843	5000	32
983	836	28	936	2187	29	889	3572	30	842	5032	32
982	864	28	935	2216	29	888	3602	30	841	5064	32
981	892	28	934	2245	29	887	3632	30	840	5096	32
980	920	28	933	2274	29	886	3662	30	839	5128	32
979	948	28	932	2303	29	885	3692	30	838	5160	32
978	976	28	931	2332	29	884	3723	31	837	5192	32
977	1004	28	930	2361	29	883	3754	31	836	5224	32
976	1032	28	929	2390	29	882	3785	31	835	5256	32
975	1060	28	928	2419	29	881	3816	31	834	5288	32
974	1088	28	927	2448	29	880	3847	31	833	5320	32
973	1116	28	926	2477	29	879	3878	31	832	5352	32
972	1144	28	925	2506	29	878	3909	31	831	5384	32
971	1172	28	924	2535	29	877	3940	31	830	5416	32
970	1200	28	923	2564	29	876	3971	31	829	5448	32

MB	ALT.	DIF.	MB	ALT.	DIF.	MB	ALT.	DIF.	MB	ALT.	DIF.
828	5480	32	781	7026	34	734	8648	35	687	10358	37
827	5512	32	780	7060	34	733	8683	35	686	10395	37
826	5544	32	779	7094	34	732	8718	35	685	10433	38
825	5576	32	778	7128	34	731	8754	36	684	10471	38
824	5608	32	777	7162	34	730	8790	36	683	10509	38
823	5640	32	776	7196	34	729	8826	36	682	10547	38
822	5672	32	775	7230	34	728	8862	36	681	10585	38
821	5704	32	774	7264	34	727	8898	36	680	10623	38
820	5736	32	773	7298	34	726	8934	36	679	10661	38
819	5768	32	772	7332	34	725	8970	36	678	10699	38
818	5800	32	771	7366	34	724	9006	36	677	10737	38
817	5833	33	770	7400	34	723	9042	36	676	10775	38
816	5866	33	769	7434	34	722	9078	36	675	10813	38
815	5909	33	768	7468	34	721	9114	36	674	10851	38
814	5932	33	767	7502	34	720	9150	36	673	10889	38
813	5965	33	766	7536	34	719	9186	36	672	10927	38
812	5998	33	765	7570	34	718	9222	36	671	10965	38
811	6031	33	764	7604	34	717	9258	36	670	11003	38
810	6064	33	763	7638	34	716	9294	36	669	11041	38
809	6097	33	762	7672	34	715	9330	36	668	11079	38
808	6130	33	761	7706	34	714	9366	36	667	11117	38
807	6163	33	760	7740	34	713	9402	36	666	11155	38
806	6196	33	759	7774	34	712	9438	36	665	11193	38
805	6229	33	758	7808	34	711	9474	36	664	11231	38
804	6262	33	757	7843	35	710	9510	36	663	11270	39
803	6295	33	756	7878	35	709	9546	36	662	11309	39
802	6328	33	755	7913	35	708	9582	36	661	11348	39
801	6361	33	754	7948	35	707	9618	36	660	11387	39
800	6394	33	753	7983	35	706	9655	37	659	11426	39
799	6427	33	752	8018	35	705	9692	37	658	11465	39
798	6460	33	751	8053	35	704	9729	37	657	11504	39
797	6493	33	750	8088	35	703	9766	37	656	11543	39
796	6526	33	749	8123	35	702	9803	37	655	11582	39
795	6559	33	748	8158	35	701	9840	37	654	11621	39
794	6592	33	747	8193	35	700	9877	37	653	11660	39
793	6625	33	746	8228	35	699	9914	37	652	11699	39
792	6658	33	745	8263	35	698	9951	37	651	11738	39
791	6691	33	744	8298	35	697	9988	37	650	11777	39
790	6724	33	743	8333	35	696	10025	37	649	11816	39
789	6757	33	742	8368	35	695	10062	37	648	11855	39
788	6790	33	741	8403	35	694	10099	37	647	11894	39
787	6823	33	740	8438	35	693	10136	37	646	11933	39
786	6856	33	739	8473	35	692	10173	37	645	11972	39
785	6890	33	738	8508	35	691	10210	37	644	12011	39
784	6924	34	737	8543	35	690	10247	37	643	12051	40
783	6958	34	736	8578	35	689	10284	37	642	12091	40
782	6992	34	735	8613	35	688	10321	37	641	12131	40

MB	ALT.	DIF.	MB	ALT.	DIF.	MB	ALT.	DIF.	MB	ALT.	DIF.
640	12171	40	592	14130	42	543	16270	45	494	18574	49
639	12211	40	591	14172	42	542	16315	45	493	18623	49
638	12251	40	590	14214	42	541	16360	45	492	18672	49
637	12291	40	589	14256	42	540	16405	45	491	18721	49
636	12331	40	588	14298	42	539	16451	46	490	18770	49
635	12371	40	587	14341	43	538	16497	46	489	18819	49
634	12411	40	586	14384	43	537	16543	46	488	18868	49
633	12451	40	585	14427	43	536	16589	[illegible]	487	18917	49
632	12491	40	584	14470	43	535	16635	46	486	18966	49
631	12531	40	583	14513	43	534	16681	46	485	19015	49
630	12571	40	582	14556	43	533	16727	46	484	19065	50
629	12611	40	581	14599	43	532	16773	46	483	19115	50
628	12651	40	589	14642	43	531	16819	46	482	19165	50
627	12691	40	579	14685	43	530	16865	46	481	19215	50
626	12731	40	578	14728	43	529	16911	46	480	19265	50
625	12771	40	577	14771	43	528	16957	46	479	19315	50
624	12811	40	576	14814	43	527	17003	46	478	19365	50
623	12851	40	575	14857	43	526	17049	46	477	19415	50
622	12891	40	574	14900	43	525	17095	46	476	19465	50
621	12931	40	573	14943	43	524	17141	46	475	19515	50
620	12971	40	572	14986	43	523	17188	47	474	19565	50
619	13012	40	571	15029	43	522	17235	47	473	19616	51
618	13053	41	570	15072	43	521	17282	47	472	19667	51
617	13094	41	569	15115	43	520	17329	47	471	19718	51
616	13135	41	568	15158	43	519	17376	47	470	19769	51
615	13176	41	567	15202	44	518	17423	47	469	19820	51
614	13217	41	566	15246	44	517	17470	47	468	19871	51
613	13258	41	565	15290	44	516	17517	47	467	19922	51
612	13299	41	564	15334	44	515	17564	47	466	19973	51
611	13340	41	563	15378	44	514	17611	47	465	20024	51
610	13381	41	562	15422	44	513	17658	47	464	20075	51
609	13422	41	561	15466	44	512	17705	47	463	20127	52
608	13463	41	560	15510	44	511	17752	47	462	20179	52
607	13504	41	559	15554	44	510	17800	48	461	20231	52
606	13545	41	558	15598	44	509	17848	48	460	20283	52
605	13586	41	557	15642	44	508	17896	48	459	20335	52
604	13627	41	556	15686	44	507	17944	48	458	20387	52
603	13668	41	555	15730	45	506	17992	48	457	20439	52
602	13710	42	554	15775	45	505	18040	48	456	20491	52
601	13752	42	553	15820	45	504	18088	48	455	20543	52
600	13794	42	552	15865	45	503	18136	48	454	20595	52
599	13836	42	551	15910	45	502	18184	48	453	20647	52
598	13878	42	550	15955	45	501	18232	48	452	20699	52
597	13920	42	549	16000	45	500	18280	48	451	20751	52
596	13962	42	548	16045	45	499	18329	49	450	20803	52
595	14004	42	547	16090	45	498	18378	49	449	20856	53
594	14046	42	546	16135	45	497	18427	49	448	20909	53
593	14088	42	545	16180	45	496	18476	49	447	20962	53
			544	16225	45	495	18525	49	446	21015	53

MB	ALT.	DIF.	MB	ALT.	DIF.	MB.	ALT.	DIF.	MB	ALT.	DIF.
445	20543	53	397	23741	58	349	26684	64	301	29989	74
444	21122	54	396	23799	58	348	26748	64	300	30061	74
443	21176	54	395	23857	58	347	26812	64	299	30139	76
442	21230	54	394	23915	58	346	26878	66	298	30217	76
441	21284	54	393	23973	58	345	26944	66	297	30295	76
440	21338	54	392	24031	58	344	27010	66	296	30373	76
439	21392	54	391	24090	60	343	27076	66	295	30451	76
438	21446	54	390	24150	60	342	27142	66	294	30529	78
437	21500	54	389	24210	60	341	27208	66	293	30607	78
436	21554	54	388	24270	60	340	27274	66	292	30685	78
435	21608	54	387	24330	60	339	27340	66	291	30763	78
434	21662	54	386	24390	60	338	27406	66	290	30841	78
433	21716	54	385	24450	60	337	27472	66	289	30919	78
432	21770	54	384	24510	60	336	27538	66	288	30977	78
431	21824	54	383	24570	60	335	27604	66	287	31075	78
430	21878	54	382	24630	60	334	27670	66	286	31153	78
429	21932	54	381	24690	60	333	27738	68	285	31231	78
428	21986	54	380	24750	60	332	27806	68	284	31309	78
427	22040	54	379	24810	60	331	27874	68	283	31387	78
426	22095	55	378	24870	60	330	27942	68	282	31465	78
425	22151	56	377	24930	60	329	28010	68	281	31544	80
424	22207	56	376	24990	60	328	28078	68	280	31624	80
423	22263	56	375	25050	60	327	28146	68	279	31704	80
422	22319	56	374	25112	62	326	28214	68	278	31784	80
421	22375	56	373	25174	62	325	28282	68	277	31864	80
420	22431	56	372	25236	62	324	28350	68	276	31944	80
419	22487	56	371	25298	62	323	28418	68	275	32024	80
418	22543	56	370	25360	62	322	28487	69	274	32104	80
417	22599	56	369	25422	62	321	28557	70	273	32184	80
416	22655	56	368	25484	62	320	28627	70	272	32264	80
415	22711	56	367	25546	62	319	28697	70	271	32344	80
414	22767	56	366	25608	62	318	28767	70	270	32424	80
413	22823	56	365	25670	62	317	28837	70	269	32504	80
412	22879	56	364	25732	62	316	28909	72	268	32584	80
411	22935	56	363	25794	62	315	28981	72	267	32264	80
410	22991	56	362	25856	62	314	29053	72	266	32744	80
409	23047	56	361	25918	62	313	29125	72	265	32824	80
408	23103	56	360	25980	62	312	29197	72	264	32904	80
407	23161	58	359	26044	64	311	29269	72	263	32984	80
406	23219	58	358	26108	64	310	29341	72	262	32064	80
405	23277	58	357	26172	64	309	29413	72	261	33144	80
404	23335	58	356	26236	64	308	29485	72	260	33226	82
403	23393	58	355	26300	64	307	29557	74	259	33308	82
402	23451	58	354	26364	64	306	29629	74	258	33390	82
401	23509	58	353	26428	64	305	29701	74	257	33472	82
400	23567	58	352	26492	64	304	29773	74	256	33554	82
399	23625	58	351	26556	64	303	29845	74	255	33638	84
398	23683	58	350	26620	64	302	29917	74	254	33722	84

MB	ALT.	DIF.	MB	ALT.	DIF.	MB	ALT.	DIF.	MB	ALT.	DIF.
253	33806	84	204	38338	102	155	44110	136	106	52099	196
252	33890	84	203	38440	102	154	44246	136	105	52299	200
251	33974	84	202	38544	104	153	44382	136	104	52499	200
250	34060	86	201	38648	104	152	44520	138	103	52701	204
249	34146	86	200	38752	104	151	44660	140	102	52905	204
248	34232	86	199	38858	106	150	44800	140	100	53316	208
247	34318	86	198	38964	106	149	44940	140	△ MB= .50		
246	34404	86	197	39070	106	148	45081	142	99.50	53421	105
245	34490	86	196	39178	108	147	45225	144	99.00	53526	105
244	34576	86	195	39286	108	146	45369	144	98.50	53631	105
243	34662	86	194	39394	108	145	45513	144	98.00	53741	110
242	34749	88	193	39502	108	144	45657	144	97.50	53851	110
241	34837	88	192	39612	110	143	45804	146	97.00	53961	110
240	34925	88	191	39721	110	142	45952	148	96.50	54071	110
239	35013	88	190	39832	112	141	46100	148	96.00	54181	110
238	35101	88	189	39944	112	140	46248	148	95.50	54291	110
237	35189	88	188	40056	112	139	46400	150	95.00	54401	110
236	35277	88	187	40168	112	138	46552	152	94.50	54511	110
235	35367	90	186	40280	112	137	46704	152	94.00	54621	110
234	35457	90	185	40392	112	136	46856	152	93.50	54733	115
233	35547	90	184	40506	116	135	47012	156	93.00	54848	115
232	35637	90	183	40622	116	134	47168	156	92.50	54963	115
231	35727	90	182	40738	116	133	47324	156	92.00	55078	115
230	35819	90	181	40854	116	132	47484	160	91.50	55433	115
229	35911	92	180	40970	116	131	47644	160	90.00	55548	115
228	36003	92	179	41086	116	130	47804	160	89.50	55653	115
227	36095	92	178	41202	118	129	47968	164	89.00	55770	120
226	36187	92	177	41321	120	128	48132	164	88.50	55890	120
225	36281	94	176	41441	120	127	48296	164	88.00	56010	120
224	36375	94	175	41561	120	126	48464	168	87.50	56130	120
223	36469	94	174	41681	120	125	48632	168	87.00	56250	120
222	36563	94	173	41801	120	124	48800	168	86.50	56370	120
221	36658	96	172	41921	120	123	48969	172	86.00	56491	120
220	36754	96	171	42044	124	122	49141	172	85.50	56616	125
219	36850	96	170	42168	124	121	49313	172	85.00	56741	125
218	36946	96	169	42292	124	120	49488	176	84.50	56866	125
217	37042	96	168	42416	124	119	49664	176	84.00	56991	125
216	37138	98	167	42541	128	118	49840	176	83.50	57116	125
215	37236	98	166	42669	128	117	50018	180	83.00	57241	125
214	37334	98	165	42797	128	116	50198	180	82.50	57366	125
213	37432	98	164	42925	128	115	50381	184	82.00	57495	130
212	37530	98	163	43053	128	114	50565	184	81.50	57625	130
211	37630	100	162	43181	128	113	50752	188	81.00	57755	130
210	37730	100	161	43311	132	112	50940	188	80.50	57885	130
209	37830	100	160	43443	132	111	51129	190	80.00	58015	130
208	37930	100	159	43575	132	110	51321	192	79.50	58145	130
207	38032	100	158	43707	132	109	51513	192	79.00	58279	135
206	38134	102	157	43839	132	108	51707	196	78.50	58414	135
205	38236	102	156	43974	134	107	51903	196	78.00	58549	135

MB	ALT.	DIF.	MB	ALT.	DIF.	MB	ALT.	DIF.	MB	ALT.	DIF
77.50	58684	135	52.50	66884	200	27.50	80502	380	20.60	86606	102
77.00	58819	135	52.00	67086	205	27.00	80892	390	20.50	86708	102
76.50	58959	140	51.50	67291	205	26.50	81284	400	20.40	86812	104
76.00	59099	140	51.00	67499	210	26.00	81684	410	20.30	86916	104
75.50	59239	140	50.50	67709	210	25.50	82090	420	20.20	87020	104
75.00	59379	140	50.00	67922	215	$\triangle P$ = .1mb			20.10	87124	104
74.50	59519	140	49.50	68137	215	25.00	82510	84	20.00	87228	104
74.00	59659	140	49.00	68352	215	24.90	82596	86	19.90	87334	106
73.50	59799	140	48.50	68567	215	24.80	82682	86	19.80	87440	106
73.00	59943	145	48.00	68782	215	24.70	82768	86	19.70	87546	106
72.50	60088	145	47.50	68997	220	24.60	82854	86	19.60	87654	108
72.00	60233	145	47.00	69207	220	24.50	82940	86	19.50	87762	108
71.50	60378	145	46.50	69432	225	24.40	83026	86	19.40	87870	108
71.00	60527	150	46.00	69669	230	24.30	83112	86	19.30	87978	108
70.50	60677	150	45.50	69899	230	24.20	83200	88	19.20	28088	110
70.00	60827	150	45.00	70132	235	24.10	83288	88	19.10	88198	110
69.50	60977	150	44.50	70367	240	24.00	83376	88	19.00	88308	110
69.00	61131	155	44.00	70607	240	23.90	83464	88	18.90	88418	110
68.50	61286	155	43.50	70848	245	23.80	83552	88	18.80	88532	114
68.00	61441	155	43.00	71093	245	23.70	83640	88	18.70	88646	114
67.50	61596	155	42.50	71338	250	23.60	83730	90	18.60	88760	114
67.00	61751	155	42.00	71585	250	23.50	83820	90	18.50	88874	114
66.50	61908	160	41.50	71835	255	23.40	83910	90	18.40	88988	114
66.00	62068	160	41.00	72087	255	23.30	84000	90	18.30	89102	114
65.50	62228	160	40.50	72346	260	23.20	84092	92	18.20	89216	114
65.00	62388	160	40.00	72608	265	23.10	84184	92	18.10	89330	114
64.50	62551	165	39.50	72873	270	23.00	84276	92	18.00	89448	118
64.00	62716	165	39.00	73141	270	22.90	84368	92	17.90	89566	118
63.50	62881	165	38.50	73411	275	22.80	84462	94	17.80	89684	118
63.00	63047	170	38.00	73685	275	22.70	84556	94	17.70	89802	118
62.50	63217	170	37.50	73966	280	22.60	84650	94	17.60	89920	118
62.00	63387	170	37.00	74243	285	22.50	84744	94	17.50	90039	118
61.50	63557	170	36.50	74531	290	22.40	84838	94	17.40	90160	122
61.00	63727	170	36.00	74823	295	22.30	84932	94	17.30	90282	122
60.50	63899	175	35.50	75120	300	22.20	84028	96	17.20	90404	122
60.00	64074	175	35.00	75420	305	22.10	84124	96	17.10	90526	122
59.50	64249	175	34.50	75725	310	22.00	85220	96	17.00	90648	122
59.00	64429	180	34.00	76032	310	21.90	85316	96	16.90	90774	126
58.50	64609	180	33.50	76344	315	21.80	85412	96	16.80	90900	126
58.00	64789	180	33.00	76660	320	21.70	85508	96	16.70	91026	126
57.50	64970	185	32.50	76980	325	21.60	85606	98	16.60	91152	126
57.00	65155	185	32.00	77304	330	21.50	85704	98	16.50	91278	126
56.50	65340	185	31.50	77634	335	21.40	85802	98	16.40	91408	130
56.00	65525	190	31.00	77972	340	21.30	85900	98	16.30	91538	130
55.50	65715	190	30.50	78314	350	21.20	86000	100	16.20	91668	130
55.00	65905	190	30.00	78664	360	21.10	86100	100	16.10	91798	130
54.50	66095	195	29.50	79022	360	21.00	86200	100	16.00	91928	130
54.00	66290	195	29.00	79382	365	20.90	86300	100	15.90	92064	136
53.50	66485	200	28.50	79748	370	20.80	86402	102	15.80	92200	136
53.00	66684	200	28.00	80122	380	20.70	86504	102	15.70	92336	136

MB	ALT.	DIF.	MB	ALT.	DIF.	MB	ALT.	DIF.
15.60	92472	136	10.60	100634	198	5.60	114578	432
15.50	92608	136	10.50	100832	198	5.50	115010	432
15.40	92744	136	10.40	101030	198	5.40	115442	432
15.30	92886	142	10.30	101240	210	5.30	115874	432
15.20	93028	142	10.20	101450	210	5.20	116338	464
15.10	93170	142	10.10	101660	210	5.10	116802	464
15.00	93312	142	10.00	101870	210	5.00	117266	464
14.90	93454	142	9.90	102080	210	4.90	117730	464
14.80	93596	142	9.80	102304	224	4.80	118194	464
14.70	93738	142	9.70	102528	224	4.70	118724	530
14.60	93880	142	9.60	102752	224	4.60	119254	530
14.50	94022	142	9.50	102976	224	4.50	119784	530
14.40	94164	142	9.40	103200	224	4.40	120352	568
14.30	94306	142	9.30	103424	224	4.30	120920	568
14.20	94454	148	9.20	103648	224	4.20	121488	568
14.10	94602	148	9.10	103872	224	4.10	122056	568
14.00	94750	148	9.00	104096	224	4.00	122696	640
13.90	94898	148	8.90	104342	246	3.90	123336	640
13.80	95046	148	8.80	104588	246	3.80	123976	640
13.70	95200	154	8.70	104834	246	3.70	124672	696
13.60	95360	160	8.60	105080	246	3.60	125368	696
13.50	95520	160	8.50	105326	246	3.50	126064	696
13.40	95680	160	8.40	105572	246	3.40	126858	794
13.30	95840	160	8.30	105818	246	3.30	127652	794
13.20	96000	160	8.20	106064	246	3.20	128464	812
13.10	96160	160	8.10	106339	275	3.10	129276	812
13.00	96320	160	8.00	106614	275	3.00	130088	812
12.90	96480	160	7.90	106889	275	2.90	131032	944
12.80	96648	168	7.80	107164	275	2.80	131976	944
12.70	96816	168	7.70	107439	275	2.70	132984	1008
12.60	96984	168	7.60	107714	275	2.60	133992	1008
12.50	97152	168	7.50	107989	275	2.50	135074	1082
12.40	97320	168	7.40	108296	307	2.40	136156	1082
12.30	97498	178	7.30	108603	307	2.30	137438	1282
12.20	97676	178	7.20	108910	307	2.20	138720	1282
12.10	97854	178	7.10	109217	307	2.10	140002	1282
12.00	98032	178	7.00	109524	307	2.00	141462	1460
11.90	98210	178	6.90	109831	307	1.90	142922	1460
11.80	98388	178	6.80	110138	307	1.80	144382	1460
11.70	98566	178	6.70	110482	344	1.70	146182	1800
11.60	98744	178	6.60	110828	346	1.60	148062	1880
11.50	98922	178	6.50	111174	346	1.50	150040	1978
11.40	99100	178	6.40	111520	346	1.40	152176	2136
11.30	99288	188	6.30	111866	346	1.30	154384	2208
11.20	99476	188	6.20	112246	380	1.20	156792	2408
11.10	99664	188	6.10	112626	380	1.10	160040	3248
11.00	99852	188	6.00	113006	380	1.00	163538	3498
10.90	100040	188	5.90	113386	380			
10.80	100238	198	5.80	113766	380			
10.70	100436	198	5.70	114146	380			

Table 2

TEMPERATURE IN N.A.C.A. STANDARD ATMOSPHERE

Altitude	Temp.(°C)	Altitude	Temp.(°C)	Altitude	Temp.(°C)
0	15			96,000	-55
1,000	13	48,000	-55	97,000	-55
2,000	11	49,000	-55	98,000	-55
3,000	9.1	50,000	-55	99,000	-55
4,000	7.1	51,000	-55	100,000	-55
5,000	5.1	52,000	-55	102,000	-55
6,000	3.1	53,000	-55	104,000	-55
7,000	1.1	54,000	-55	104,987	-55
8,000	- 0.8	55,000	-55	106,000	-52.9
9,000	- 2.8	56,000	-55	108,000	-48.5
10,000	- 4.8	57,000	-55	110,000	-43.9
11,000	- 6.8	58,000	-55	112,000	-39.5
12,000	- 8.8	59,000	-55	114,000	-35.0
13,000	-10.8	60,000	-55	116,000	-30.6
14,000	-12.7	61,000	-55	118,000	-26.1
15,000	-14.7	62,000	-55	120,000	-21.6
16,000	-16.7	63,000	-55	122,000	-17.1
17,000	-18.7	64,000	-55	124,000	-12.7
18,000	-20.7	65,000	-55	126,000	- 8.2
19,000	-22.6	66,000	-55	128,000	- 3.7
20,000	-24.6	67,000	-55	130,000	+ .72
21,000	-26.6	68,000	-55	132,000	+ 5.2
22,000	-28.6	69,000	-55	134,000	+ 9.7
23,000	-30.6	70,000	-55	136,000	+14.2
24,000	-32.5	71,000	-55	138,000	+18.6
25,000	-34.5	72,000	-55	140,000	+23.1
26,000	-36.5	73,000	-55	142,000	+27.6
27,000	-38.5	74,000	-55	144,000	+32.1
28,000	-40.5	75,000	-55	146,000	+36.5
29,000	-42.5	76,000	-55	148,000	+41.0
30,000	-44.4	77,000	-55	150,000	+45.5
31,000	-46.4	78,000	-55	152,000	+50.0
32,000	-48.4	79,000	-55	154,000	+54.4
33,000	-50.4	80,000	-55	156,000	+58.9
34,000	-52.4	81,000	-55	158,000	+63.4
35,000	-54.3	82,000	-55	160,000	+67.8
35,332	-55	83,000	-55	162,000	+72.3
36,000	-55	84,000	-55	164,000	+76.8
37,000	-55	85,000	-55		
38,000	-55	86,000	-55		
39,000	-55	87,000	-55		
40,000	-55	88,000	-55		
41,000	-55	89,000	-55		
42,000	-55	90,000	-55		
43,000	-55	91,000	-55		
44,000	-55	92,000	-55		
45,000	-55	93,000	-55		
46,000	-55	94,000	-55		
47,000	-55	95,000	-55		

Table 3

Table of flows in gm/hr. from "Spinnerette Orifices"

dia. (in inches)	Q (actual) in gm/hr.			
	at 24 Hd.	at 22" Hd.	at 20" Hd.	at 18" Hd.
.003	35	33.5	32	30.5
.004	62.8	60	57	54.5
.005	97.5	93.5	88.8	84.5
.006	141	134	128	122
.007	192	184	175	166
.008	251	241	229	217
.009	317	303	289	274
.010	392	375	358	340
.011	474	453	433	410
.012	564	540	515	488

$$Q \text{ (actual) gm/hr.} = C_d \,(\text{dia.}")^2 \,(\text{hd.}")^{\frac{1}{2}} \times 1.003 \times 10^6$$

(C_d varies from .78 to .82)

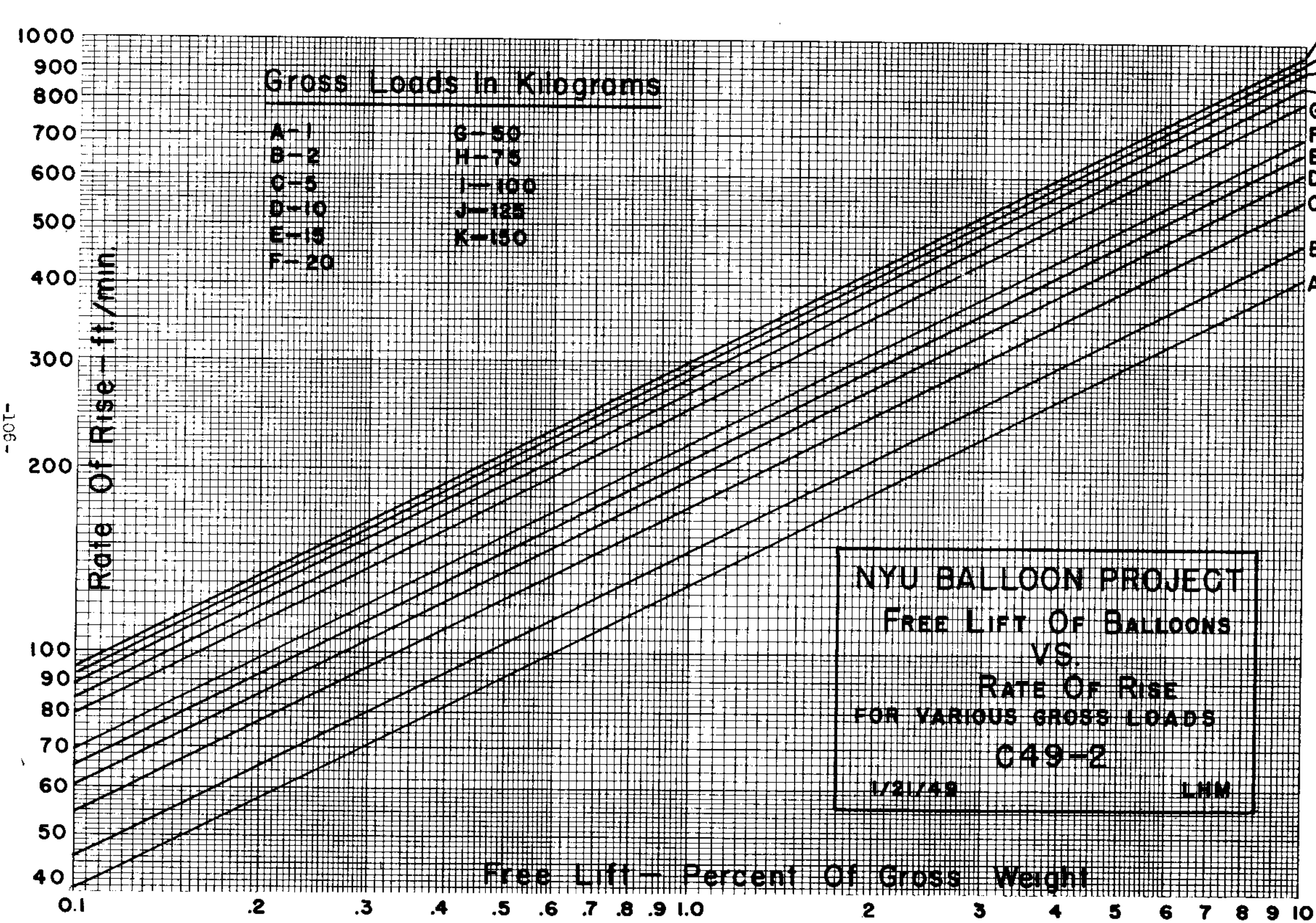
C_d (mean) = .80 (used above)

$$\frac{Q_1}{Q_2} = \left(\frac{\text{hd.}_1}{\text{hd.}_2}\right)^{\frac{1}{2}}$$

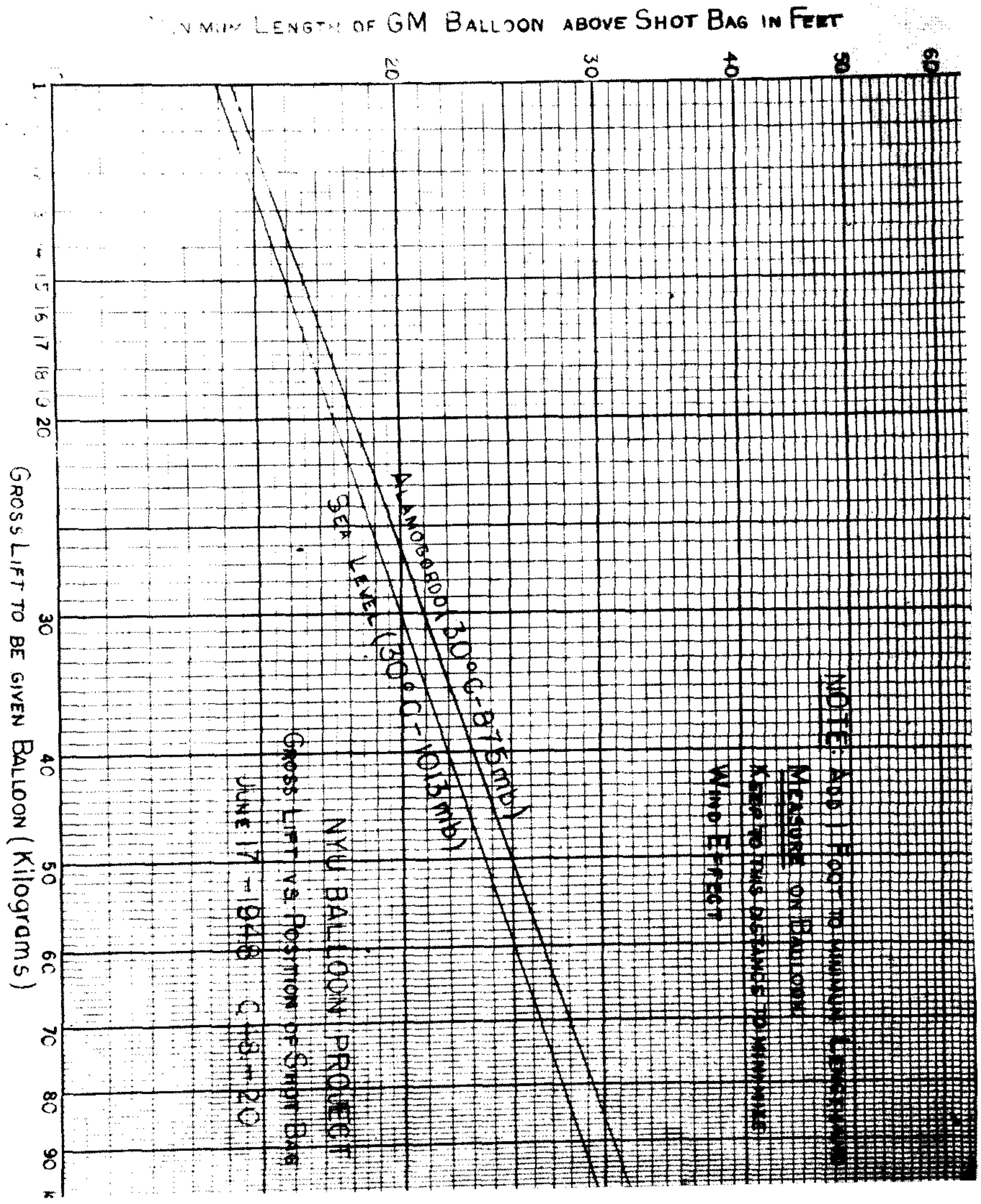
Table 4

BALLOON DATA

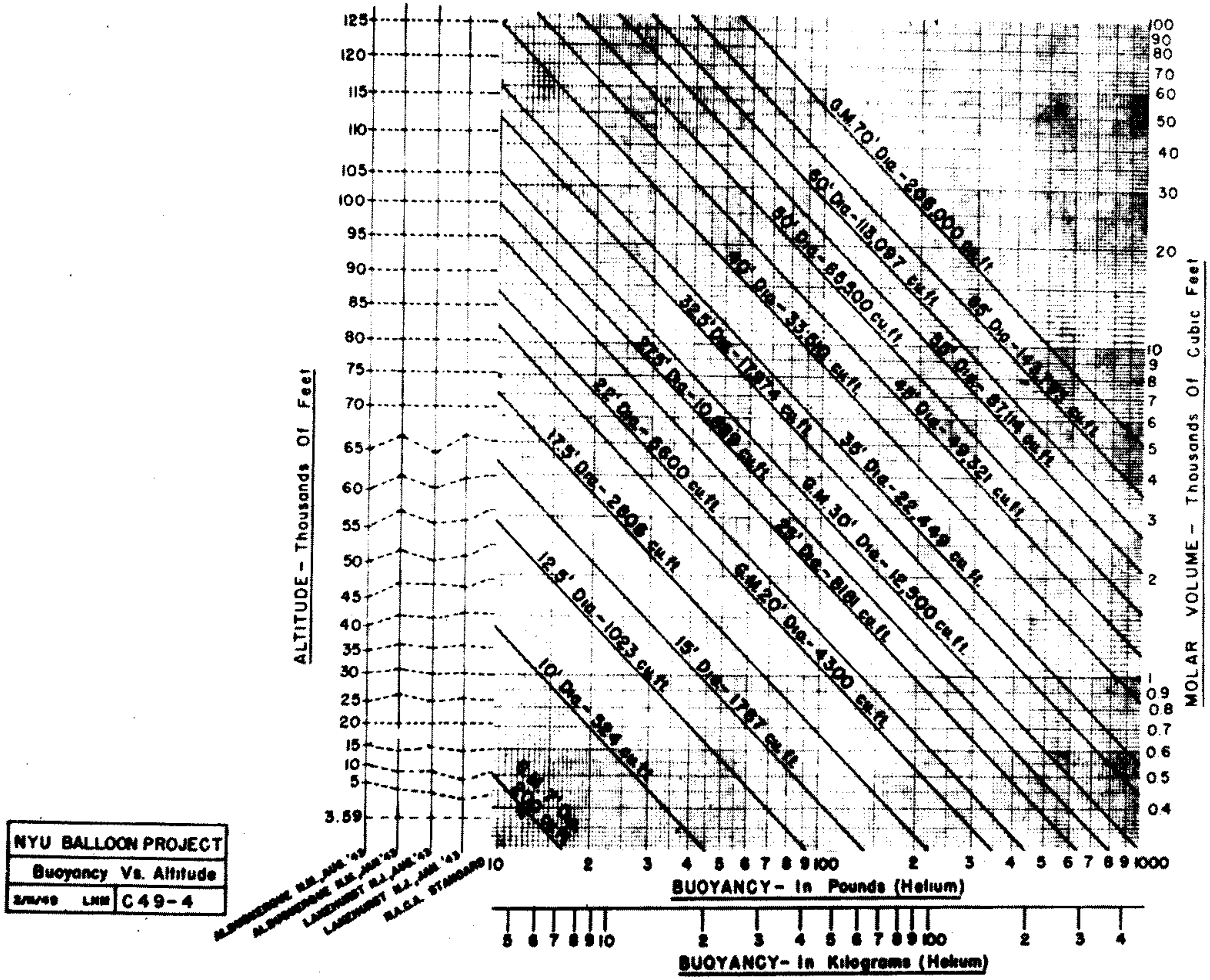
General Mills Nominal Diameter ft.	Actual Volume cu.ft.	Balloon Weight kg.	Estimated Gross Load Limit kg.	Altitude Range ft.
7	200	0.6	1.5 to 5	38,000 to 0
20	4300	3.8 to 5.0	7 to 36	68,000 to 37,000
30	12,700	8.9	12 to 60	82,000 to 50,000
70	200,000	41 to 54	50 to 175	110,000 to 84,000



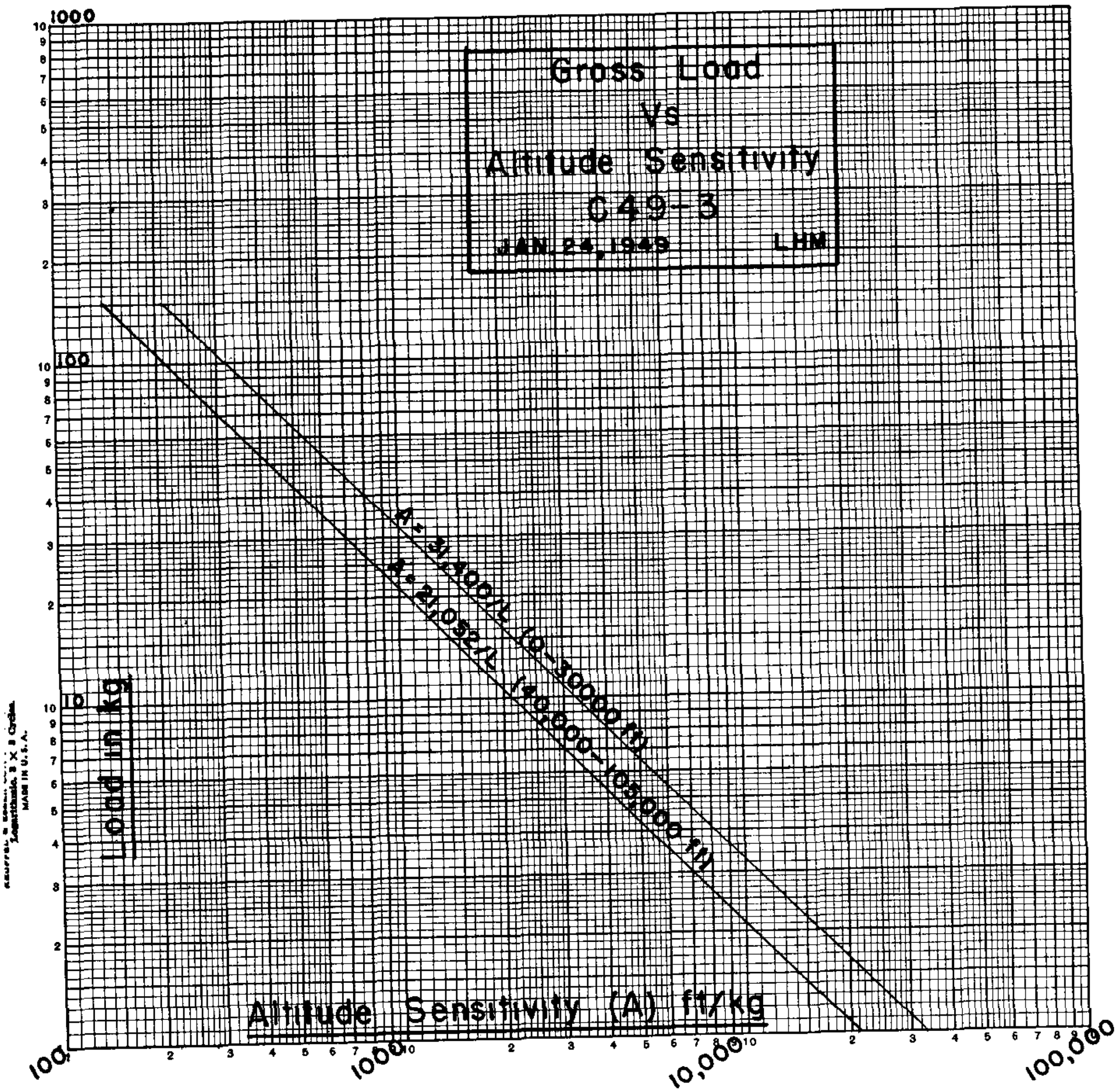
Gross Loads In Kilograms
A—1
B—2
C—5
D—10
E—15
F—20
G—50
H—75
I—100
J—125
K—150
Rate Of Rise — ft./min.
Free Lift — Percent Of Gross Weight
NYU BALLOON PROJECT
FREE LIFT OF BALLOONS
VS.
RATE OF RISE
FOR VARIOUS GROSS LOADS
C49-2
1/21/49
LHM


LENGTH OF GM BALLOON ABOVE SHOT BAG IN FEET
20
30
40
50
60
1
15 16 17 18 19 20
30
40
50
60
70
80
90
GROSS LIFT TO BE GIVEN BALLOON (Kilograms)
ALAMOGORDO (30°C - 875mb)
SEA LEVEL (30°C - 1013mb)
NOTE: ADD
MEASURE ON BALLOON
WIND EFFECT
NYU BALLOON PROJECT
GROSS LIFT VS. POSITION OF SHOT BAG
JUNE 17 - 1948

Graph 2


NYU BALLOON PROJECT
Buoyancy Vs. Altitude
C49-4
ALTITUDE - Thousands Of Feet
MOLAR VOLUME - Thousands Of Cubic Feet
BUOYANCY - In Pounds (Helium)
BUOYANCY - In Kilograms (Helium)
G.M. 70' Dia - 200,000 cu.ft.
60' Dia - 113,097 cu.ft.
65' Dia - 143,793 cu.ft.
50' Dia - 65,400 cu.ft.
55' Dia - 87,114 cu.ft.
40' Dia - 33,510 cu.ft.
45' Dia - 49,321 cu.ft.
32.5' Dia - 17,974 cu.ft.
35' Dia - 22,449 cu.ft.
27.5' Dia - 10,889 cu.ft.
G.M. 30' Dia - 12,500 cu.ft.
22' Dia - 5600 cu.ft.
25' Dia - 8181 cu.ft.
17.5' Dia - 2806 cu.ft.
G.M. 20' Dia - 4300 cu.ft.
12.5' Dia - 1023 cu.ft.
15' Dia - 1767 cu.ft.
10' Dia - 524 cu.ft.
N.A.C.A. STANDARD

Graph 3



Gross Load
Vs
Altitude Sensitivity
C49-3
JAN 24, 1949
LHM
A = 31,400/L (0-30000 ft)
A = 21,032/L (40,000-105,000 ft)
Load in kg
Altitude Sensitivity (A) ft/kg
1000
100
10
100
1000
10,000
100,000

Graph 4

Note: On flights made in February, 1949, spring bow appendix closers were used successfully with rates of rise exceeding 1000 feet per minute. Of those described on page 10, this type of appendix stiffener is now recommended.

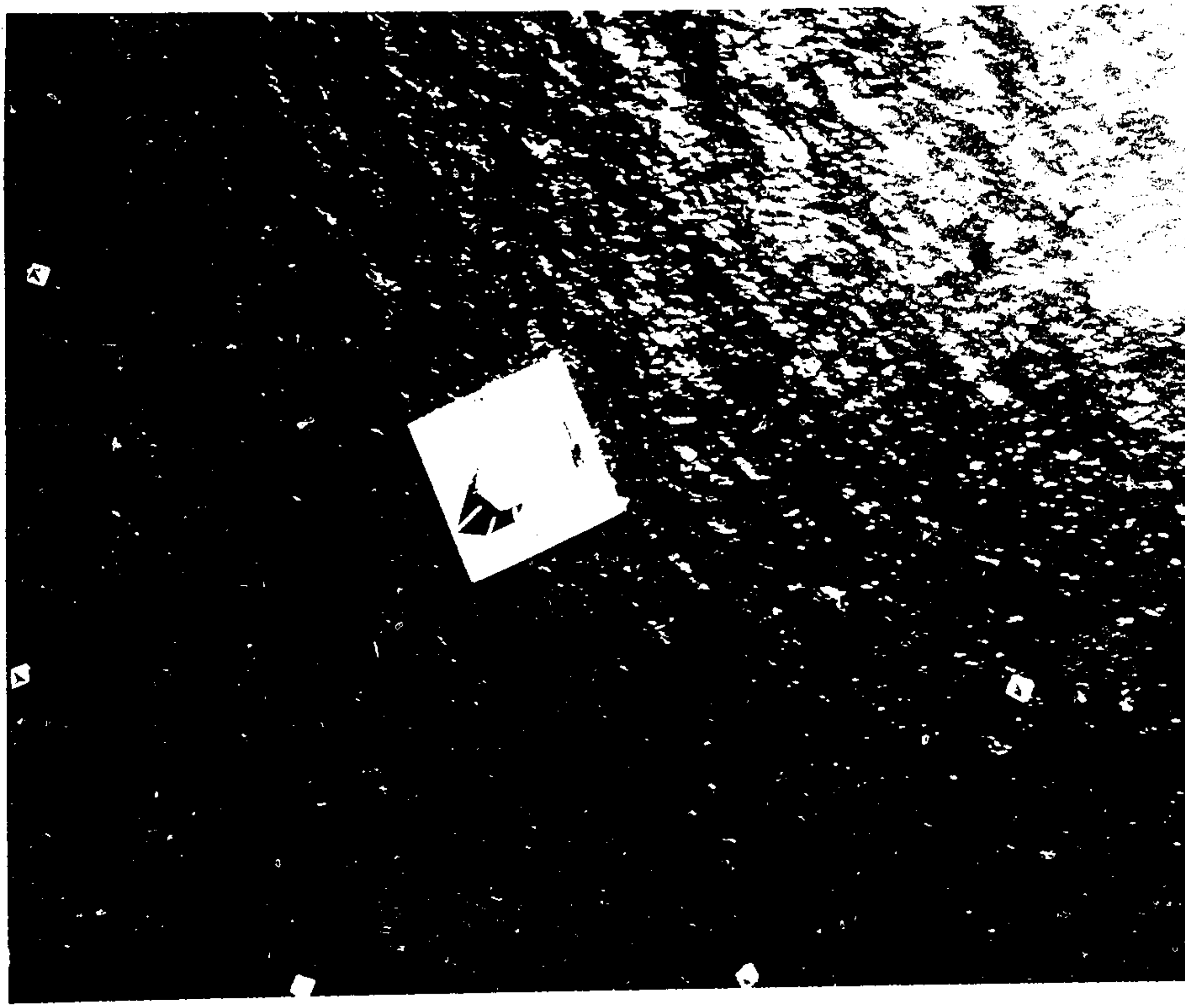
25

Combined History [Selected Pages]
509th Bomb Group and Roswell
Army Airfield
September 1947

UNCLASSIFIED

COMBINED HISTORY
509TH BOMB GROUP
AND
ROSWELL ARMY AIR FIELD

1 SEPTEMBER 1947 THROUGH 30 SEPTEMBER 1947



[redacted]

CHAPTER XIII

VISITORS and EXECUTIVE CALENDAR

3 September 1947 - Colonel Blanchard and Lt. Haut went to Artesia where Colonel Blanchard was guest speaker at the Artesia Woman's Club luncheon

3 September 1947 - Colonel Pelham D. Glasford, Eighth Air Force Air Inspector's Office and Lt. Colonel John A. Roberts, Assistant Chief of Staff, arrived for general familiarization with various activities on the field as pertains to their respective jobs.

3 September 1947 - Col. John D. Ryan, A-3; Lt. Colonel Calvin W. Fite, Jr., Lt. Colonel Carl V. Ekstrand, Lt.Colonel Ray C. Milton, Major Leroy S. English, Captain Floyd R. Creasman, Captain James W. Brady, all from Headquarters Eighth Air Force, arrived here for a conference and inspecting and coordination with various sections on the base. Lt. Colonels Harman and Ord arrived from Alburquerque for the conference.

4 September 1947 - The above-named group departed for Forth Worth and Tucson.

5 September 1947 - Mr. Lawrence A. Deason, Sr., liason representative from San Antonio, called on Colonel Blanchard.

10 September 1947 - Mr. Peoples, Mr. Hackman and First Lieutenant Thompson from Air Material Command arrived on the field to inspect Air Material Command installations and to confer with Lt. Colonel Briley.

11 September 1947 - Captain J. P. Morgan, from Headquarters Eighth Air Force, was here to confer with the Engineering Officer, Captain Peterson, in regard to the de-icer boot on C-54 aircraft.

12 September 1947 - Inspection teams from this Base inspected various Base activities, organizations, and installations.

15 September 1947 - Troops from Roswell Army Airfield marched in a parade in the City of Roswell at 1030 for the benefit of the Chavez County Memorial Youth Center.

15 September 1947 - A meeting of S-1, S-2, S-3, S-4, DCO, Executive, Air Inspector, Adjutant and Commanding Officers of the 393rd, 830th, and 715th Bomb Squadrons was held in the Control Room to discuss the reorganization.

[redacted]

33

"Mensuration Working Paper," with
Photo and Drawing
February 15, 1994

Customer Code: 12592

Mensuration Working Paper

TARGET NAME	ROSWELL, N.MX.		
IMAGE ID	FWST(UTA) NEG.ENV. #2026, NEG #1	DATE RETURNED	26-JUL-94
IMAGERY ANALYST	LT. MCANDREW — DIVISION DOD	PHONE	703-693-2013
IMAGERY SCIENTIST		PHONE	

COMPARATOR	N/A	MEASUREMENTS		HOURS	
INTERGRAPH	MSB2	MEASUREMENTS	17	HOURS	7

SIGNATURE DATE

- STEREO ☐
- TERRESTRIAL ☒
- RUSH JOB ☒
- Q-JOB ☐
- IA ASSISTED ☐
- CABLE/PUBLICATION ITEM ☐

MENSURATION RESULTS:

PHOTOGRAPH AND CAMERA INFORMATION:

GROUND PHOTOGRAPHS- FWST(UTA) NEG. ENV. #2026, NEG #1- #4. TAKEN JULY 8,1947.
CAMERA TYPE- SPEED GRAPHIC (4" X 5" FORMAT)
NOMINAL FOCAL LENGTHS- 127mm, 135mm and 150mm(MOST COMMON).

THE FOCAL LENGTH CALCULATED FOR THE CAMERA USED TO TAKE PHOTOGRAPH NEG. #1 IS EQUAL TO **121mm**.

ASSUMPTIONS:

BROWN WRAPPING PAPER ON FLOOR UNDER OBJECT OF INTEREST IS ASSUMED TO HAVE A WIDTH OF 35.5 ± 3".
RADIATOR ON LEFT SIDE OF THE PHOTOGRAPH IS ASSUMED TO HAVE A TOTAL HEIGHT OF 28 ± 2".

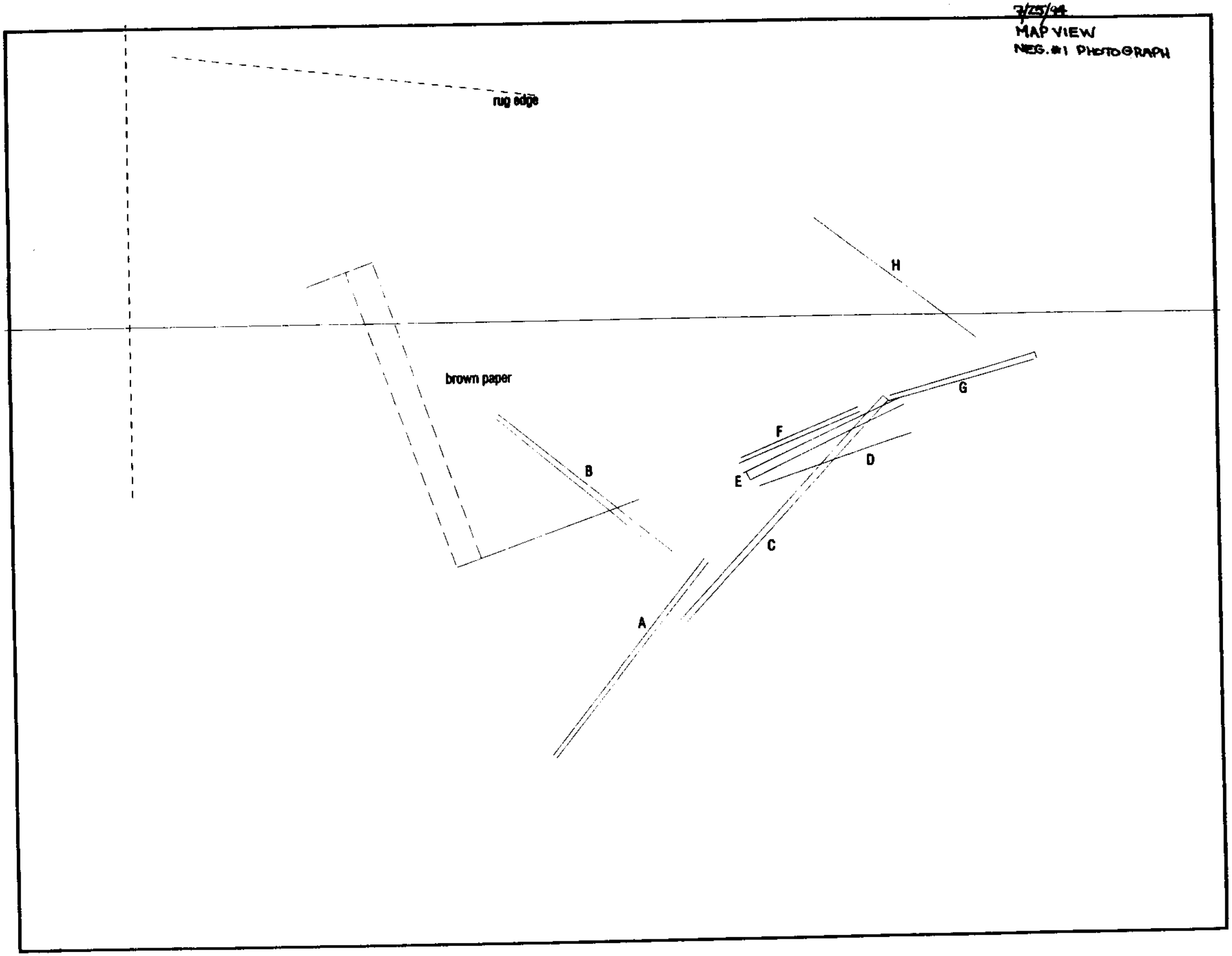
MEASUREMENTS:

STICK MEASUREMENTS:

	LENGTH		WIDTH	
ID.	(M)	(IN)	(M)	(IN)
A	0.7	27.6"	0.01	0.4"
B	0.6	23.6"	0.01	0.4"
C	0.9	35.4"	0.02	0.8"
D	0.5	19.7"	——	——
E	0.5	19.7"	0.02	0.8"
F	0.4	15.7"	0.01	0.4"
G	0.4	15.7"	0.01	0.4"
H	0.6	23.6	——	——
BASE BOARD	0.1	3.9"	——	——

NOTE: THE ***ACCURACY STATEMENT*** IS 10% OF THE REPORTED LENGTHS AND WIDTHS.


Radiator
Rug Edge
Brown Edge
.H
.G
.F
.E
.D
.B
.C
.A


7/25/94
MAP VIEW
NEG. #1 PHOTOGRAPH
rug edge
brown paper
H
G
F
E
D
B
C
A

PHOTOGRAPH SECTION

General Carl A. Spaatz, Commanding General, U.S. Army Air Forces, 1947. Gen Spaatz was the Chief of Staff, United States Air Force, 1947–1948. A review of his personal and official documents, including highly classified daily briefings for the summer of 1947, do not in any way suggest that U.S. Army Air Forces recovered a flying saucer or its alien occupants. *U.S. Air Force Photo.*

Lt. Gen. Hoyt S. Vandenberg, Deputy Commander, U.S. Army Air Forces, 1947. General Vandenberg served as Chief of Staff, United States Air Force 1947–1953. He is alleged to have directed the recovery of a flying saucer at Roswell Army Air Field on July 8, 1947. A review of his official daily activities calendar revealed his knowledge of a reported flying saucer recovery on July 7 in Texas, an incident that he later determined to be a hoax. Records do not support the claim that he had any similar involvement on July 8, as charged by crashed saucer conspiracy theorists *(see Atch 15)*.
U.S. Air Force Photo.

General Nathan F. Twining, Commanding General, Air Matériel Command, 1947. General Twining was Chief of Staff, United States Air Force, 1953–1957. UFO theorists allege that General Twining altered his plans unexpectedly in July 1947 to go to New Mexico to oversee the recovery of a flying saucer. However, records indicate that Twining went to New Mexico in July 1947, along with several other general officers, to attend the Nuclear Bomb Commanders Course. He received orders to attend this course more than a month *before* the alleged "incident" occurred *(see Atch 14). U.S. Air Force Photo.*

Maj. Gen. Curtis E. LeMay *(left)* and **Brig. Gen. Roger M. Ramey** are shown here while serving in Kharagpur, India, during World War II. *U.S. Air Force Photo.*

General Curtis E. LeMay was Deputy Chief of Air Staff for Research and Development, U.S. Army Air Forces, in 1947, and later Chief of Staff, United States Air Force, 1961–1965. As Deputy Chief of Air Staff for Research and Development, LeMay had a strong influence on the high-priority Project MOGUL *(see Apps 8 and 9)*. He also maintained close associations throughout his career with former subordinates from World War II bombing campaigns, including Brig. Gen. Roger M. Ramey and Col. William H. Blanchard.

Brig. Gen. Roger M. Ramey was the Commanding General, Eighth Air Force, in 1947. He is alleged to have participated in the cover-up of the recovery of an extraterrestrial vehicle by substituting debris from an ordinary weather balloon for that of an alien spacecraft. In fact, General Ramey displayed the original debris recovered from the ranch, which came from a MOGUL balloon train. Ramey withheld only the components that would have compromised the highly sensitive project *(see Atch 16)*.

Col. William H. Blanchard, Commander 509th Bomb Group, 1947, and later, Vice Chief of Staff, United States Air Force, 1965–1966. As commander of Roswell Army Airfield and the 509th Bomb Group, Blanchard is alleged to have secretly directed the recovery of a flying saucer while pretending to be on leave. Records indicate that Blanchard *was* on leave, departing Roswell on July 8 and returning on July 23, 1947 *(see Atch 11). U.S. Air Force Photo.*

Maj. Gen. Clements McMullen, Deputy Chief of Staff, Strategic Air Command, 1947. General McMullen is alleged to have directed General Ramey to cover up the recovery of an extraterrestrial craft and crew. After an extensive search, the "Command Correspondence" file for the period was located. This file contained privileged and classified information of the highest order between McMullen and Ramey—it contained no information to support the outrageous claim.

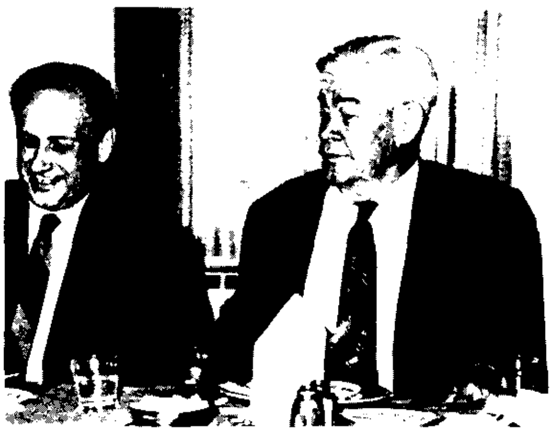
Brig. Gen. Donald N. Yates, Chief, Air Weather Service, 1947, and later, Deputy Director of Defense for Research and Engineering. Crashed saucer theorists contend Yates participated in a conspiracy by confirming the weather balloon explanation for the mysterious debris. They also contend that the debris recovered by the rancher was transported to Andrews AAF, MD (near Washington, DC), to be examined by high government officials including the President. In reality, Andrews AAF was the home of the Army Air Forces Air Weather Service and would be a probable location for debris, which contained components of weather equipment, to be identified. *U.S. Air Force Photo.*

Project MOGUL Field Operations Director **Albert P. Crary** maintained a journal of his professional activities including Project MOGUL research in the summer of 1947. Portions of his journal provided details necessary to reconstruct events not available from published MOGUL reports *(see App 17)*. In addition to his work for the Air Force, this world-enowned scientist is credited with significant contributions to the study of Polar regions; a research center at McMurdo Station, Antarctica was recently named in his honor.

Albert P. Crary *(left)* and technician **Phil Chantz** taking a break during Project MOGUL operations at White Sands Proving Ground, NM, July 1947.

Dr. W. Maurice Ewing, preeminent geophysicist and oceanographer. It was Ewing who first conceptualized the military significance of the atmospheric sound channel. His proposal, made directly to the Commanding General U.S. Army Air Forces, General Carl Spaatz, was well received and resulted in the initiation of Project MOGUL *(see App 6). Photo Courtesy of Woods Hole Oceanographic Institution.*

The distinguished scientists **Albert P. Crary** *(left)* and **Dr. W. Maurice Ewing** collaborated at various scientific research institutions throughout their careers, in addition to performing their work for the U.S. Air Force. In the course of their collaborations, these men had affiliations with Lehigh University, Columbia University, and Woods Hole Oceanographic Institution.



Dr. Athelstan F. Spilhaus *(left)* and **Col. Marcellus Duffy** appear here serving as members of HQ USAAF Liaison Group to the U.S. Army Signal Corps, Saipan, in 1944. *Photo Courtesy of Mrs. Emily Duffy.*

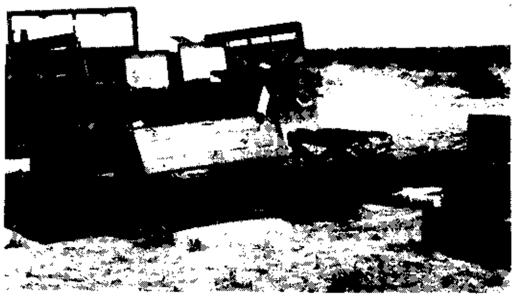
Dr. Athelstan F. Spilhaus, Director of Research at New York University, oversaw but had no direct involvement in the activities of the NYU Balloon Group or the alleged incident. He did, however, serve on various high-level panels which set military and national policy, including the USAF Scientific Advisory Board (1953–1957). When asked, for the purpose of this report—and released from any security oaths he may have taken—if he ever had knowledge of a recovery of an extraterrestrial vehicle or its occupants by the U.S. Government, his unqualified response was "no."

Col. Marcellus Duffy, a highly capable scientific research officer, was a MOGUL project officer. Maj. Gen. Curtis LeMay, Deputy Chief of Air Staff for Research and Development, turned to Colonel Duffy to make adjustments to MOGUL after the project's progress was determined to be inadequate *(see App 8)*.

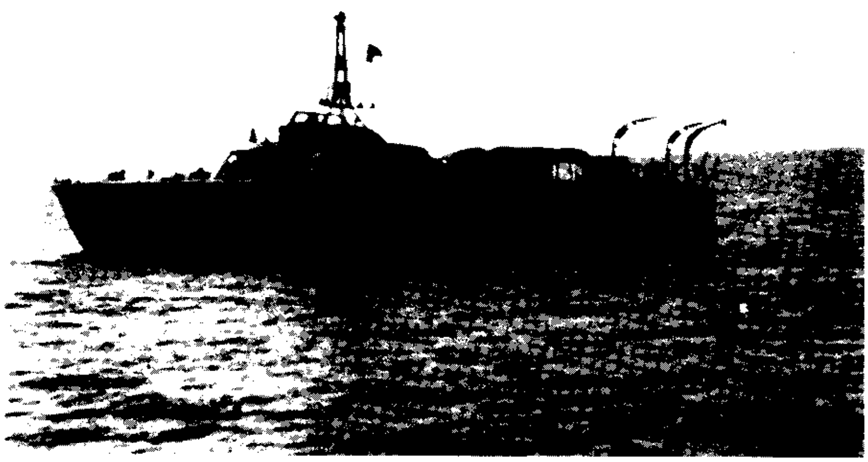
Capt. Albert C. Trakowski who succeeded Colonel Duffy as MOGUL Project Officer, confirmed in a recent interview that the debris mistaken for part of a flying saucer was flown to Wright Field (now Wright-Patterson AFB) OH, not for scientific analysis as alleged by UFO theorists, but for Colonel Duffy's personal identification. *Photo Courtesy of Col. Albert Trakowski.*

MOGUL Project Scientist Dr. James Peoples. Peoples's decision not to bring the radiosonde tracking equipment for the NYU field trip in June 1947 prompted Project Engineer C.B. Moore to attach additional radar targets to the MOGUL balloon trains. The targets, seldom used in the continental United States, were recovered by the rancher and mistaken to be part of a flying saucer.

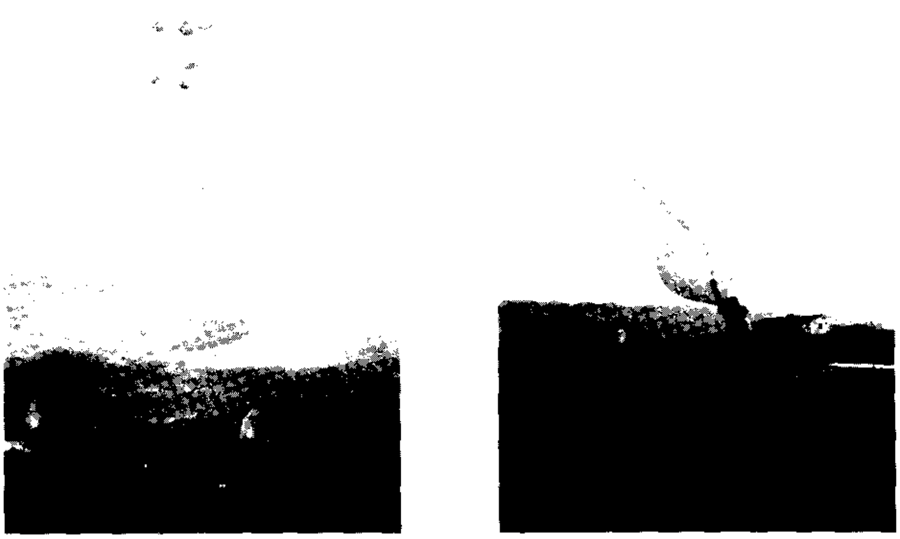
Charles B. Moore, NYU Constant-Level Balloon Project Engineer. Moore pioneered the use of polyethylene balloons for upper atmospheric research. He launched NYU flight No. 4 on June 4, 1947, which was the balloon train most likely to have caused what is known today as the "Roswell Incident." Moore is presently Professor Emeritus of Atmospheric Physics at New Mexico Institute of Mining and Technology, Soccoro, NM. *Photo Courtesy of C.B. Moore.*



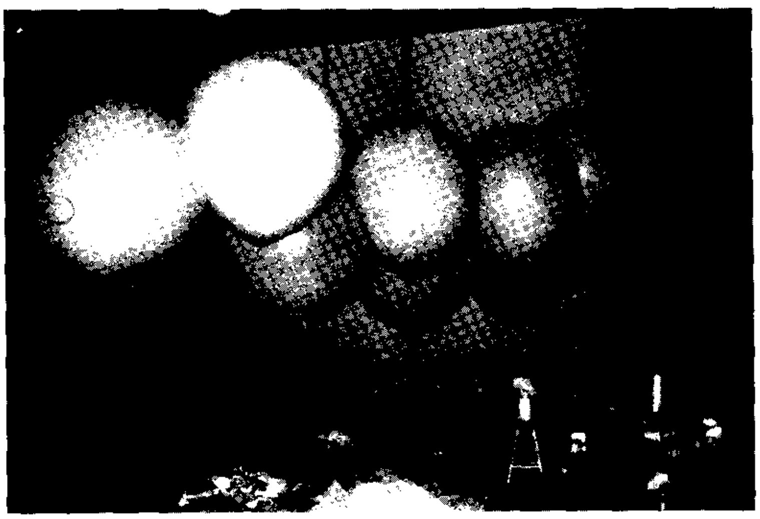
Sitting in the back of the truck *(left)* is a U.S. Army GR–3 Sound Ranging Set, normally used by field artillery observation units but adapted for use in Project MOGUL. The set was employed for the MOGUL operations at White Sands Proving Ground in July 1947. **The detonation, or "shot"** *(right),* of 500 pounds of TNT was monitored at White Sands Proving Ground, NM, in July 1947, by Project MOGUL balloon and ground-based sensors. *Photo Collection of Albert P. Crary.*



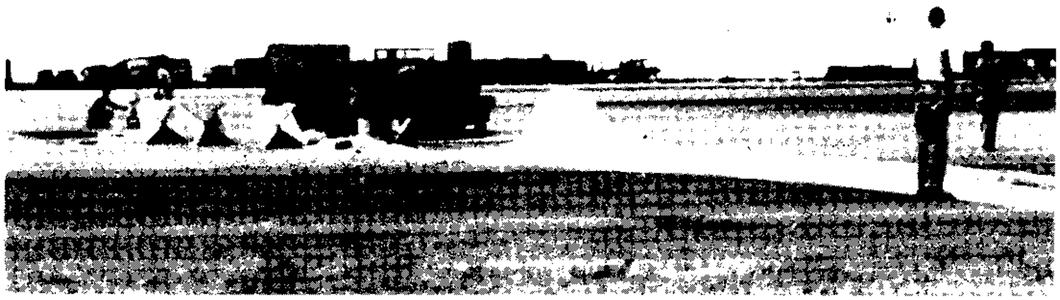
This modified PT boat that was assigned to Project MOGUL is shown here off Block Island, RI. Col. Marcellus Duffy eliminated it and several others from the project when Headquarters U.S. Army Air Forces expressed concerns over the progress of MOGUL under the previous project officer. *Photo collection of Albert P. Crary.*



Launch of Project MOGUL neoprene balloons, Alamogordo AAF, NM, June 1947. While awaiting the experimental polyethylene balloons, NYU engineers utilized long trains of the smaller neoprene balloons as a stopgap method of placing their acoustic sensors in the upper atmosphere. These balloon trains consisted of a variety of equipment and measured more than 600 feet long *(see Atch 25)*. *Photo Collection of Albert P. Crary.*

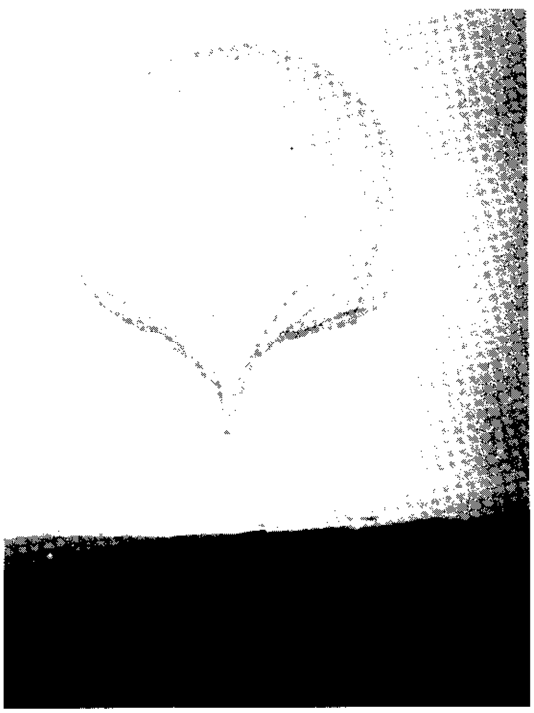


Standard 350-gram meteorological weather balloons in the North Hangar at Alamogordo AAF for use by Project MOGUL in June 1947. Although the balloons themselves were common, the remainder of the equipment on the MOGUL trains was experimental or had been recently placed in service *(see Atch 25)*. It would not be unusual for individuals uninvolved in the development of these devices not to recognize them. *Photo Courtesy of C.B. Moore.*

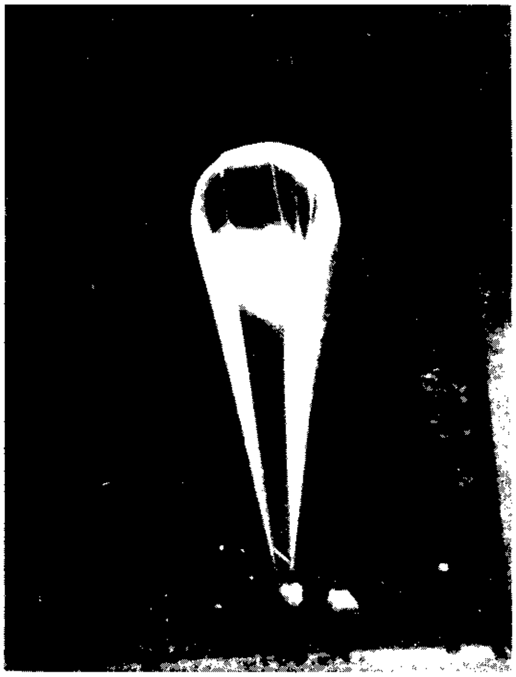


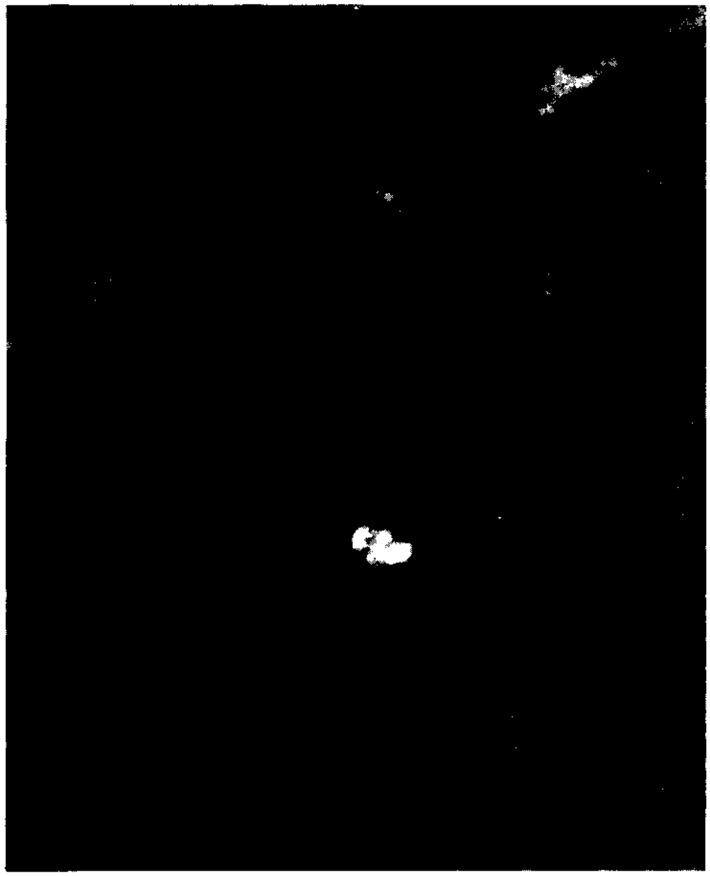
A New York University launch crew prepares a MOGUL balloon train for flight (Holloman AFB, NM, 1948). The three ML–307C/AP corner reflectors *(left)* are of the type that W.W. "Mac" Brazel recovered on a ranch near Corona, NM, in June 1947.

C.B. Moore, New York University Constant Level Balloon Project Engineer *(left and standing),* adjusts an AN/FMQ–1 radiosonde receiver/recorder. The absence of this equipment on the first NYU field trip in June 1947 (it was left behind in New York due to space limitations of the B-17 aircraft) prompted Moore to attach additional ML–307C/AP corner reflectors to MOGUL flights. The addition of the oddly constructed reflectors, intended to enhance radar returns, contributed to the confusion when Mogul Flight No. 4 returned to earth and was mistaken for a part of a flying saucer. Moore *(right and reaching down)* prepares experimental Project MOGUL microphones for launch (Holloman AFB, Alamogordo, NM, July 1948).

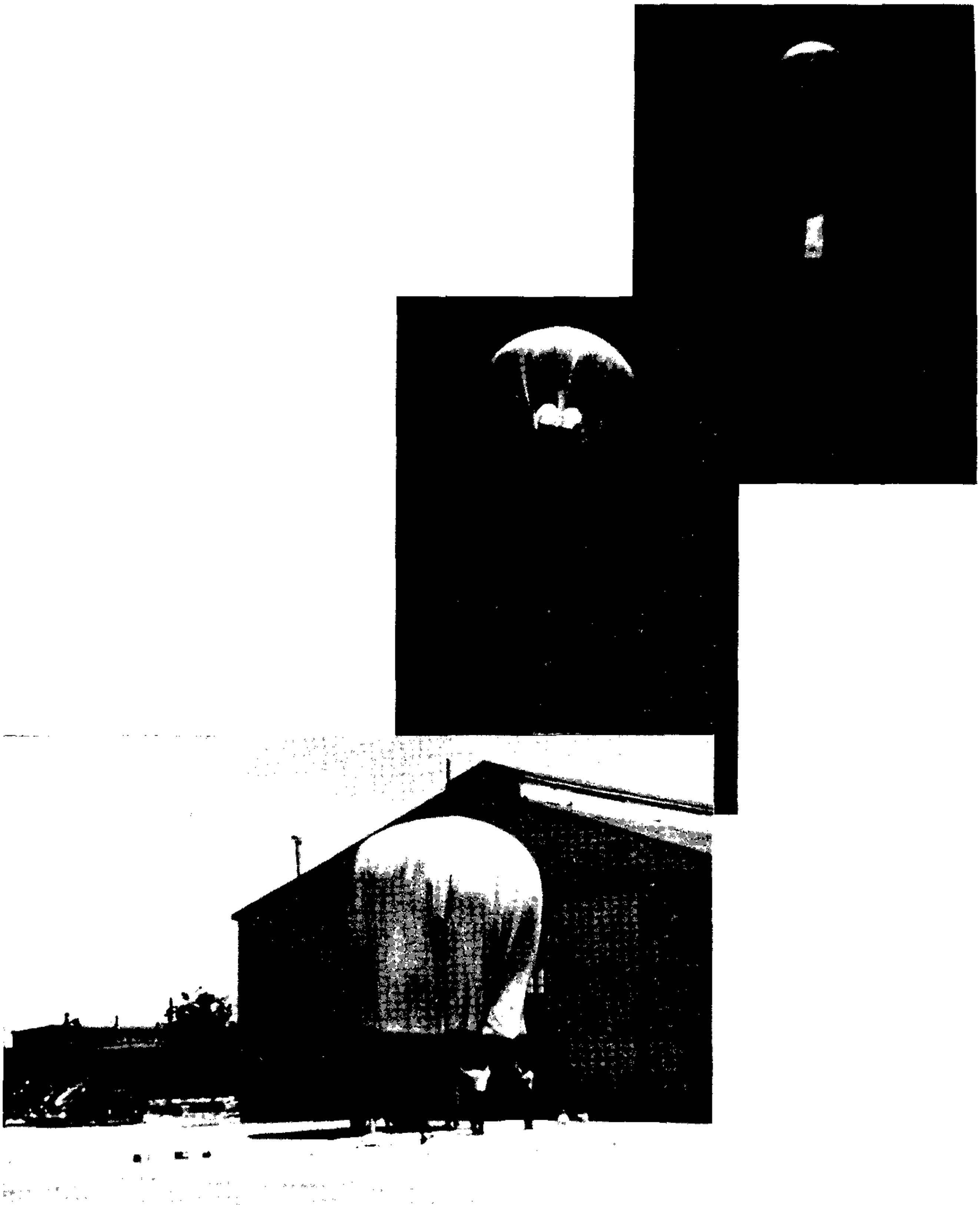


This 15-foot polyethylene balloon *(left)* and **70-foot polyethylene balloon** *(above)* are representative of the type used extensively by Project MOGUL. It is this variety of balloon that caused many UFO sightings due to their flat, spherical appearance when viewed from the ground.



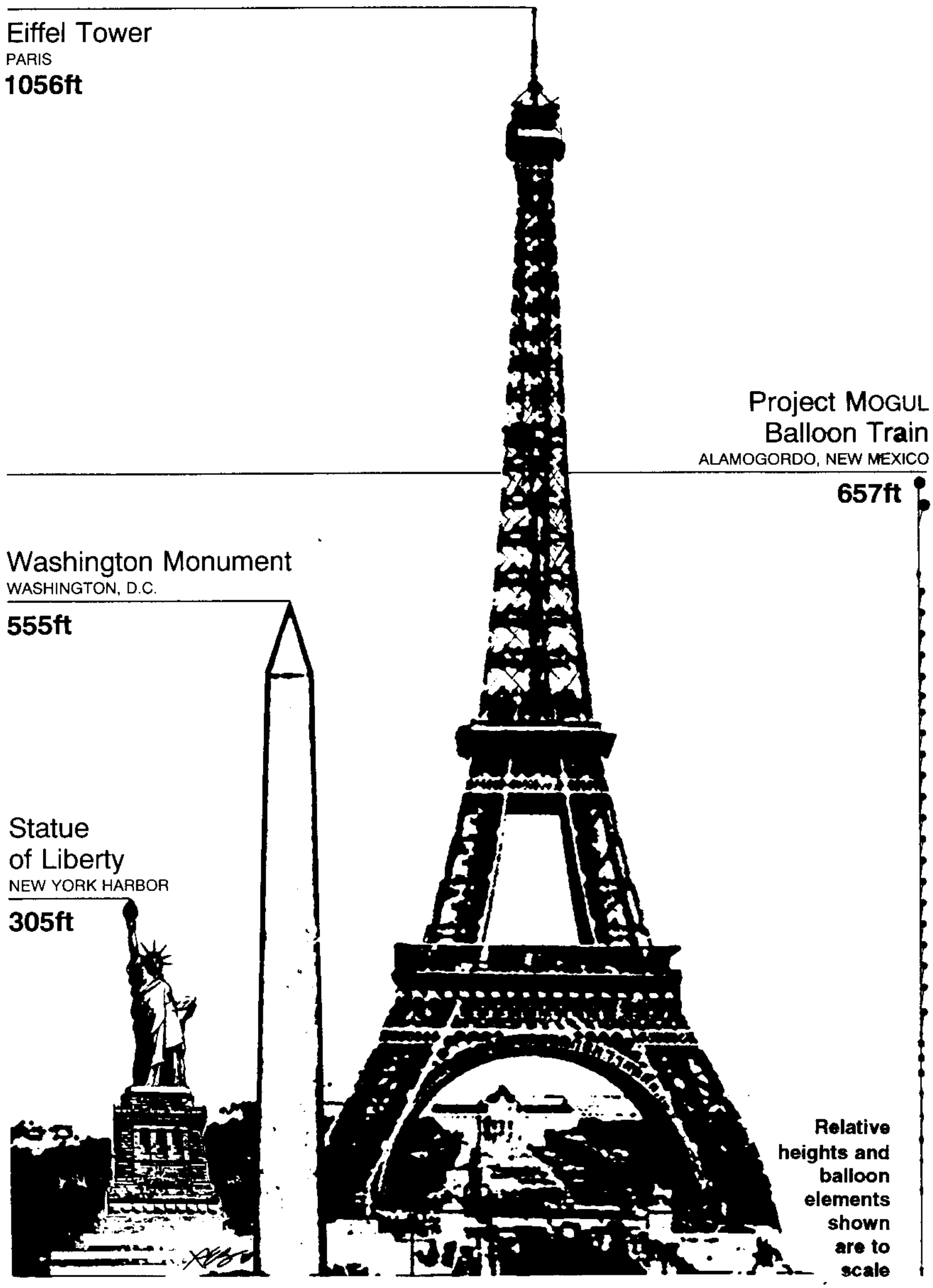


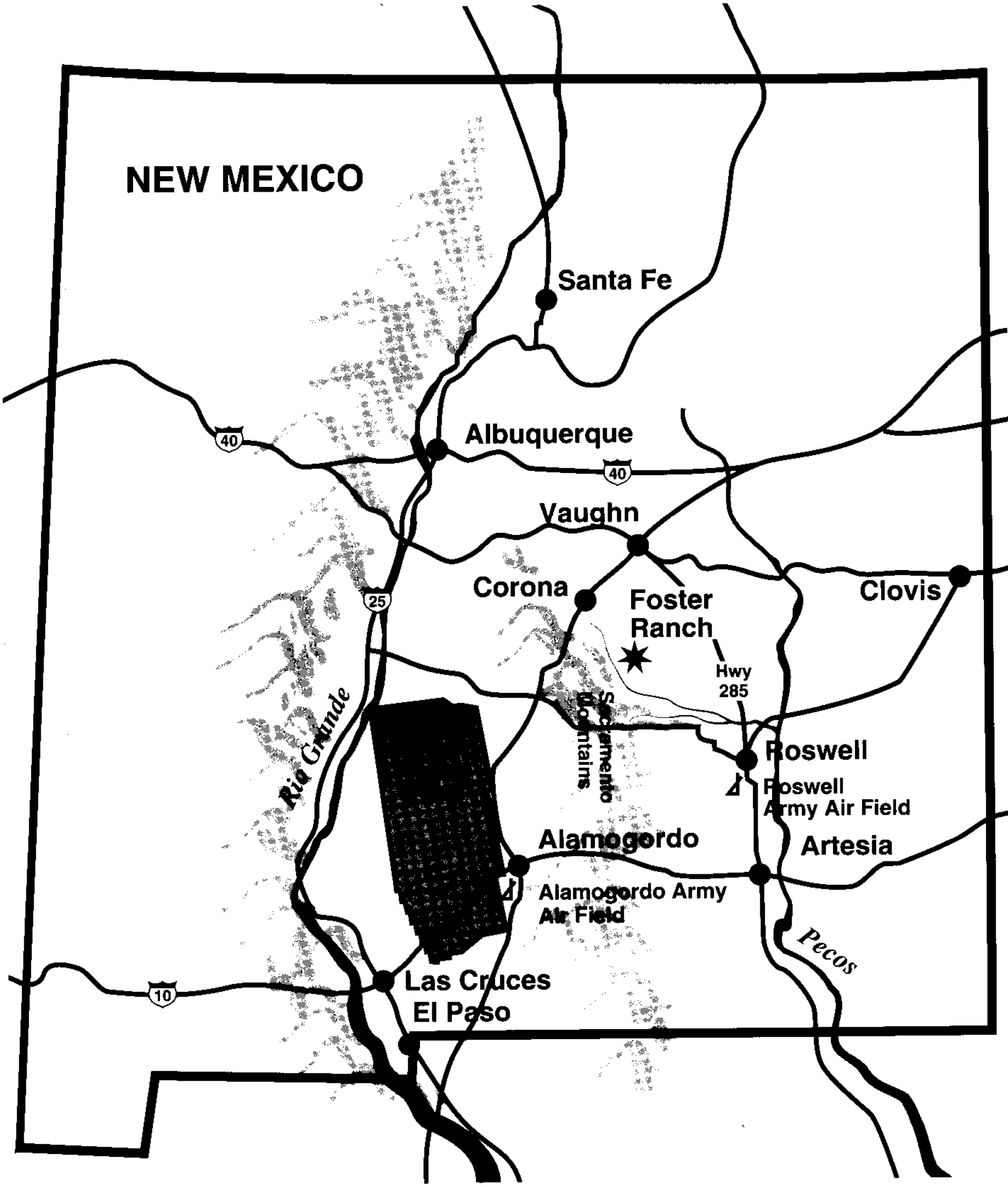
A blimp hangar at Lakehurst Naval Air Station, NJ *(left),* contains a Project MOGUL balloon during its preparation for flight. **Lying on the desert floor near Roswell, NM,** in July 1948 *(right)* is a Project MOGUL balloon. Due to the prevailing westerlies, MOGUL balloons often descended in the vicinity of Roswell after launch from Alamogordo. The unpredictability and hazards to aircraft presented by the balloons prompted the Civil Aviation Administration (now the Federal Aviation Administration) to conduct a hearing addressing safety concerns of balloons landing in the Roswell area *(see App 13, pp. 43–44).*



Also used during Project MOGUL were balloons developed by Seyfang Laboratories, the inventors of the first Macy's Thanksgiving Day Parade balloons. These balloons were easily mistaken for flying saucers due to their shape and metallic exterior coating.

Project MOGUL balloon train components *(above)* can be compared with the debris recovered from the Foster ranch and shown at Forth Worth Army Airfield with Maj. Jesse Marcel. Crashed saucer theorists allege that the debris depicted with Major Marcel is not the original debris collected from the Foster ranch. A switch is alleged to have taken place after the material arrived from Roswell AAF. However, detailed analysis and interviews with individuals who viewed and handled the debris verify it to be completely consistent with the materials launched by Project MOGUL and subsequently recovered at the Foster ranch.


Eiffel Tower
PARIS
1056ft
Project MOGUL
Balloon Train
ALAMOGORDO, NEW MEXICO
657ft
Washington Monument
WASHINGTON, D.C.
555ft
Statue
of Liberty
NEW YORK HARBOR
305ft
Relative heights and balloon elements shown are to scale



NEW MEXICO
Santa Fe
Albuquerque
40
40
Vaughn
Corona
Foster
Ranch
Clovis
25
Hwy
285
Rio Grande
Sacramento
Mountains
Roswell
Roswell
Army Air Field
Alamogordo
Artesia
Alamogordo Army
Air Field
Pecos
Las Cruces
El Paso
10